Transnational shared common themes for environmental and sustainability research and innovation

CASRI Deliverable D 3.1

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CASRI

Collaborative Action coordinating and enhancing systemic, actionable and transversal Sustainability Research and Innovation

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0.3	27/06/2025	Syke	Revised version	Internal review comments included, technical and language editing.
1.0	30/06/2025	Syke	Final version	Final version

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EXECUTIVE SUMMARY

The Horizon Europe Coordination and Support Action CASRI – Collaborative Action coordinating and enhancing systemic, actionable and transversal Sustainability Research and Innovation – aims to strengthen the role of Environmental Protection Agencies (EPAs) in the European Research Area (ERA). Together with key partners and stakeholder, CASRI fosters a more integrated, strategic, and practice-oriented research and innovation (R&I) agenda for Europe's sustainability transitions.

This report synthesizes and evaluates suggestions for environmental and sustainability R&I priorities, collected across 14 European national and regional contexts by the CASRI project. The aim is to identify relevant themes and potential key issues that address systemic, actionable, and transversal knowledge needs, taking into account societal relevance, the ability to contribute to grand challenges, and future responsiveness.

The CASRI project gathered expert views on knowledge needs and gaps, focusing on four predefined themes of environmental and sustainability R&I, while also welcoming new perspectives.

In total, over 600 individual proposals for priorities were collected. This report analyses the stated demands and identifies key issues that are relevant beyond individual countries or stakeholder groups. Based on content analysis, key issues were formulated and sorted using the guiding principles of CASRI. This initial selection was further discussed and validated in an international expert workshop consulting 60 participants of 47 different organisations.

The following aspects relevant to the future CASRI R&I agenda are emphasized under the four CASRI predefined themes that organised the data collection:

- "Resilient, net-zero, circular production systems": a broad range of knowledge needs with a greater weight on traditional (mission-oriented) R&I objectives, particularly focused on industrial ecosystems and innovation. Broader public-oriented innovation needs come in second and tend to be focused on wider societal change, generally oriented towards equity and actor influence. Security of resource supply appears as an overarching concern.
- "Biodiversity and climate": while both areas are already well-established in science and policy, specific attention should be given to their intersectionality and scaling out. Key issues include data utilization, governance of climate–biodiversity interactions, and regulatory and institutional frameworks for policy implementation. Ecological restoration and resilience of soil, water, and forest ecosystems are also central concerns.
- "Sustainable urbanisation": solutions to environmental and sustainability challenges in urban areas. This involves the integrated strategic coordination of diverse actors and sectoral knowledge, adequate resources and land-use and legal planning processes to pursue shared goals of climate adaptation, environmental resilience, and social justice.
- "Nature- and environmentally friendly energy transition": while the energy transition requires technological innovation, also transdisciplinary research and transformative action are needed. This includes social justice dimensions as well as aspects of governance, societal acceptance, environmental effects of energy infrastructure, land use and comparing scenarios. Overall, there is a need for active societal engagement to effectively balance ecological, economic, and social challenges.

Several priorities were also presented outside or cross-cutting these four predefined themes. Key issues identified beyond these original themes included integrative assessments of trade-offs, synergies, and risks—thus emphasizing preparedness; the management of geopolitical and other conflicts; environmental and ecosystem health; the potential for scaling up experiments; and innovation diffusion. The creation of policy-relevant understanding of transformative change and the role of the social sciences was also emphasized. Additionally, the reconfiguration of the economic system—highlighting overconsumption of natural resources, sufficiency and justice—was brought forward.

Overall, this report provides a comprehensive synthesis of shared transnational environmental and sustainability key issues. Simultaneously, it places the reported key issues in the context of current perceived public priorities, such as security, democracy and participation, regulatory efficiency & competitiveness and digitalisation. As such, it delivers the analytical foundation for selecting issues with strategic potential for European transnational collaboration. The findings will significantly inform the development of the CASRI Strategic Research and Innovation Agenda.

KEYWORDS

Biodiversity, Circular economy, Climate change, Collaboration, Energy, Environment, Innovation, Interaction, Participation, Policy, Priorities, Production systems, Research, Sustainability, Transnational, Transition, Transversal, Urbanisation

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ABBREVIATIONS

AI	Artificial Intelligence
B&C	Biodiversity and Climate
EC	European Commission
EEA	European Environment Agency
EGD	European Green Deal
ES R&I	Environmental and Sustainability Research and Innovation
EPA	Environmental Protection Agency
EU	European Union
HEU	Horizon Europe
NEFET	Nature & Environmentally Friendly Energy Transition
NKS	National Key Stakeholders
R&I	Research and Innovation
RNZCPS	Resilient, Net-Zero, Circular Production Systems
SDGs	Sustainable Development Goals
SPPI	Science, Policy and Practice Interaction
SRIA	Strategic Research and Innovation Agenda
SU	Sustainable Urbanisation

Transnational shared common themes for environmental and sustainability research and innovation

1 Introduction

1.1 Background, key concepts and aim

This deliverable (D3.1) of the CASRI Work Package 3 (WP3) on Transnational Commons synthesises and analyses the national (Austria, Bulgaria, Finland, France, Germany, Ireland, Italy, Montenegro, the Netherlands, Slovakia, Switzerland) and regional level (Basque country, Flanders, Wales) reports produced in WP2. National comprehensive reports These reports present results from desk research, expert interviews, and workshops on Environmental and Sustainability Research and Innovation (ES R&I) needs, funding, and Science-Policy-Practice Interaction (SPPI) under various national and regional contexts. These national comprehensive reviews are available as a single document published as D2.1 of the CASRI-project (Maring et al., 2025). The results presented in D2.1 are used as material for further analysis, together with National Key Stakeholder workshop organised in Helsinki between 26-27 May 2025.

The specific aim of this deliverable is to identify, prioritise and verify relevant themes and transnationally shared key issues for ES R&I, focusing on converging needs at European level. Transnational is here understood a phenomena or process that involves multiple countries or operates beyond the confines of any single nation. It can encompass social activities or physical systems that are recognised as potentially important under different national contexts. The concept highlights connections and relationships between individuals, organizations, and institutions across nations.

The CASRI project started with four pre-defined environmental and sustainability (ES) themes, reflecting current understanding of European policy priorities and state-of-the-art scientific knowledge of ES challenges. Since these themes are general level constructs, they overlap with each other. The themes (section 1.3) included “Resilient, net-zero, circular production systems”, “Climate and biodiversity”, “Sustainable urbanization”, and “Nature & environmentally friendly energy transition”. The methodology also allowed for inclusion of other potential ES R&I needs and gaps. These themes are described in D2.1 (Maring et al., 2025). The overall approach and methods of the CASRI project are described in CASRI Deliverable 6.1 (Firus et al., 2024).

The concept of theme refers here to an internally coherent general level subject area clustering together several individual ES R&I priorities (see chapter 1.3). These priorities are collected from different European national contexts through a bottom-up process. They may include specific topics, subjects or issues with distinctive features. ES R&I priority may also consist of a specific methodology, analytical framework, tool or perspective that can be applied to different issues.

Below the results from the national comprehensive reviews (Maring et al., 2025) are summarised, the relevance of the pre-defined themes is assessed and need for reorganising the themes or adding themes, more detailed sub-themes or more overarching themes is evaluated. The analysis is based on a data-driven approach. Here the ambition was not to create a theory-driven framework that aims to systematically capture all potentially relevant ES R&I priorities in coherent and comprehensive way, but to identify those transnationally shared R&I key issues that were considered of importance by the national key stakeholders (NKS). This will inform a matchmaking process with potential R&I funders (forthcoming CASRI D3.2) and the formation of the Strategic R&I Agenda (SRIA) aimed at the European level.

The results presented here should not be interpreted as country / region positions, but views of the selected NKS. Furthermore, the results do not represent official views of Environmental Protection Agencies (EPAs) or other institutions involved with the CASRI project.

Key criteria for the identification of the themes and prioritised key issues include equally their societal and policy relevance, the ability to contribute to grand environmental and sustainability challenges and the future responsiveness. As various assessments and scientific studies have clearly shown, the evidence base is already sufficient to justify rapid and large-scale actions focusing on human activities increasingly leading to unsustainable pressures on climate (IPCC, 2023; Ripple et al., 2024), biodiversity (IPBES, 2024) and resource use (UNEP, 2024). It is also clear that such a socio-technical transition towards ecological sustainability (or, better, socio-ecological transition) is needed globally and in Europe, and it needs to be locally tailored, considering different contexts and development paths across and within nations (Rockström et al., 2023; Kallis et al., 2025, 8th EU Environmental Action Programme). Besides based on the current science-based understanding, the prioritised themes should also address a) systemic, b) actionable and c) transversal premises of the CASRI project (Figure 1).

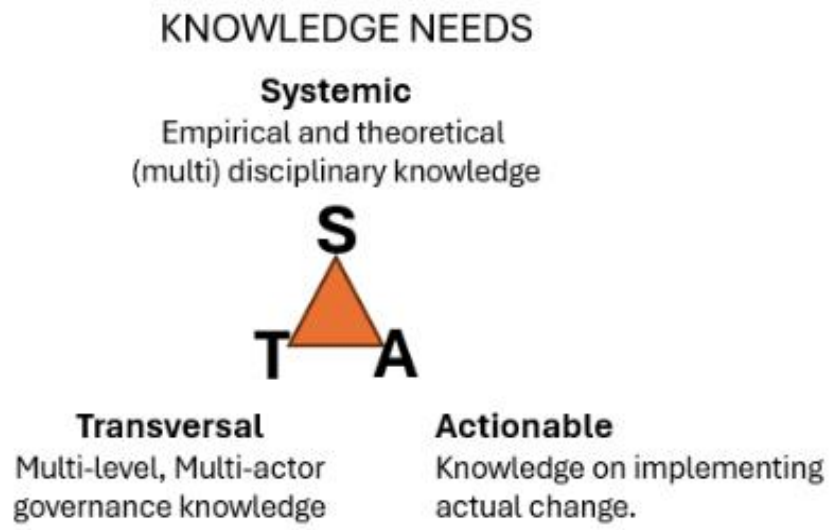


FIGURE 1 - SYSTEMIC, ACTIONABLE AND TRANSVERSAL KNOWLEDGE

CASRI project addresses three key premises emphasising the need for systemic, actionable and transversal knowledge.

Transitional sustainability challenges must be addressed systemically: Knowledge on systemic links is essential for tackling sustainability challenges. A system is here understood as any group of interacting, interrelated or interdependent parts that form a complex, unified whole with a specific purpose. CASRI aims to develop systemic and holistic solutions to the global socio-economic crises that will simultaneously address the long-term environmental challenges such as climate change, decarbonization, biodiversity, energy, circular economy and zero pollution ambition. Systemic approach emphasises the need for a better understanding of interactions between systems, including spill-overs and trade-offs as well as benefits and synergies. It also invites interdisciplinary work combining insights from various fields and transdisciplinary work inviting various stakeholders working on solutions to the crises. Moreover, systemic approach addresses future challenges through foresight that integrates the various systems.

Knowledge must be actionable: Addressing Europe's unprecedented environmental and sustainability challenges require policies, investments and concrete action. It is apparently not sufficient to address the existing knowledge gaps, a new knowledge system for systemic transformation is needed. CASRI facilitates action bridging research, policy and practice. Public and private decision-makers may overlook science-based solutions to environmental challenges instead of embracing them. This is often the case when potential solutions come with short-term losses, even when those losses are compensated by long-term gains. As natural resources become more strained, decision-makers increasingly face balancing acts between competing environmental considerations and political and economic interests. CASRI seeks for science-based knowledge that is not only easily available and understandable, timely and relevant for specific need but also hard to sideline in decision-making even when strong competing claims or interests prevail.

Transversal – multi-level and multi-actor governance is needed for sustainability transformation. CASRI is based on an idea of transversal integration of the different societal challenges and needs with bottom-up approach. Networks engaging public and private societal actors in multi-level governance in a transdisciplinary way are needed in R&I co-creation and implementation.

This report is organised as follows: First, the four pre-selected CASRI themes and logic for identifying additional themes are briefly introduced (Chapter 1.2). This is followed by a description of the materials used (Chapter 1.3) and methods applied (Chapter 1.4). Chapter 2 presents the analysis of country results. Chapter 3 critically refines the results based on inputs from experts. Chapter 4 reflects on the societal relevance given the review of results and expert discussions. Chapter 5 provides a summary and next steps.

1.2 Role of this report within the CASRI workflow

This report on transnational shared common themes is a milestone in the CASRI project and particularly within Work Package 3 on Transnational Commons. It provides an enriched, synthesised and prioritised analysis of transnationally shared environmental and sustainability research and innovation (ES R&I) priorities across 14 European national and regional contexts. However, it is not intended to be the final or complete product of this work package. Rather, it serves as a foundational step toward two key next outcomes: (1) **Deliverable 3.2**, which will identify a smaller set of high-priority, actionable themes suitable for transnational matchmaking of actors to implement projects and potential co-funding; and (2) the **Strategic Research and Innovation Agenda (SRIA)** to be developed in Work Package 4 on matching topics, funding opportunities.

As outlined in the CASRI's Description of Work (see Firus et al., 2024), D3.1 reflects the results of a process combining desk research and interviews and workshops with NKS (WP2 results), further analysis and a transnational co-creation workshop with selected NKS held in Helsinki in May 2025. The analysis and workshop helped to refine thematic priorities, identify emerging cross-cutting themes (such as **Security**, **Competitiveness and Regulatory Efficiency**, **Digitalisation & AI**, and **Democracy and Participation**), and assess the relevance of systemic, actionable, and transversal knowledge types.

The next phase of WP3 (Task 3.3; Towards transnational coalitions) will focus on evaluating the prioritised themes through further consultation with CASRI's Core Group involving key experts from all WPs and International Advisory Board. The outcome of that process—Deliverable 3.2—will present the selected topics deemed most promising for transnational R&I coalitions and policy impact. Simultaneously, WP4 will begin shaping the SRIA, using insights from this report and the forthcoming D3.2 to develop strategic recommendations for national and EU-level research and policy agendas.

Readers of this report are therefore encouraged to interpret this deliverable as a **strategic evidence base** rather than a finalized agenda. Its purpose is to support decision-making in the forthcoming CASRI activities that aim to catalyse targeted, collaborative action at the intersection of science, policy, and practice.

1.3 The predefined CASRI themes

Given the thematic breadth of ES R&I on the one hand and the restricted resources of the project on the other, CASRI has identified four general level themes as starting points (Table 1). The four themes were selected based on the following criteria: Themes clearly contribute to UN 2030 Agenda and the Sustainable Development Goals (SDGs). They interlinkage several Horizon Europe Global Challenges and Missions. They require urgent action to prevent scenarios of high probable risk for severe harm. They have significant cross-border impacts. They are characterised by strategies, goals and policy activities involving trade-offs and synergies. They are relevant for Environmental Protection Agencies (EPAs). Finally, in line with so-called EU Taxonomy Regulation, they carry a considerable potential for preventive measures and for the implementation of the "do no significant harm" principle.

The predefined themes are: Resilient, net-zero, circular production systems; Biodiversity and climate; Sustainable urbanisation; Nature & environmentally friendly energy transition. These four themes are intersecting and partially overlapping but they provide distinctive framings for key

sustainability issues. They were considered useful starting points for stakeholder involvement since they provide an initial framework that captures many of the current global challenges of environmental sustainability and at the same time allow inclusion of a variety of different topics and emerging issues (Table 1). Importantly, a fifth theme for "other" topics was used to specifically collect views on issues falling outside of the four pre-defined themes. More detailed description of the themes is found from the CASRI D2.1 (Maring et al., 2025).

TABLE 1. THE FOUR PREDEFINED CASRI THEMES

Pre-selected theme	Rationale for the theme	Links to global challenges and HEU Missions	Primary links to SDGs
Resilient, net-zero, circular production systems	Transforming Europe's production system from a linear, fossil-based system to one that is resilient, emission neutral and circular within the next few decades lies at the heart of the European Green Deal (as found in Circular Economy Action Plan, Critical Raw Materials Act, Net-Zero Industry Act). There is currently an absence of ongoing, coordinated and overarching exchange of best-practice experiences.	Climate Mission + Clusters 4, 5, 6 + Pillar III, EIT KIC e.g. Raw Materials, Manufacturing	SDGs 8, 9, 12, 13
Biodiversity and climate	Climate change accelerates biodiversity loss. Degraded ecosystems undermine nature's ability to regulate emissions. Policies must simultaneously address both crises. Potential exists in the interlinkages between the climate, biodiversity and pollution as well as the SDGs. The cross-border impact on value-chains through which the EU is externalising both its emissions and biodiversity loss is relevant.	Climate Mission (also Soils, Oceans, Cities), Clusters 5 and 6	SDGs 12, 13, 14, 15
Sustainable urbanisation	Climate protection, land management, circularity and nature protection impact the quality of life in cities. Aspects such as urban green and building materials influence health, natural resource use, energy, mobility, land take. Knowledge pertaining to the effective steering of urban systems and the involved stakeholders is crucial for sustainability that is recognized by local citizens as much as societies as a whole.	Cities, Climate, Soils Missions, More or less all 6 Clusters, NEB initiative	SDGs 3, 11, 12, 13
Nature & environmentally friendly energy transition	Renewable energy production may conflict with other environmental targets (e.g. zero pollution, biodiversity). Due to the accelerating energy transition speed and stalling of progress regarding biodiversity, potential conflicts need to be resolved. Environmentally friendly energy transition affects various sectors: biomass, solar, wind, hydropower and links to broader societal issues (energy consumption for food, transport, tourism etc.). Segmentation at the institutional level, which exists in most countries, hinders a systemic approach.	Climate Mission (also Soils, Oceans), Clusters 5 and 6	SDGs 7,9, 13,15

Note: Descriptions of the Sustainable Development Goals (SDGs): https://sdgs.un.org/goals

1.4 Materials

The data summarised and analysed in Chapter 2 comprises of results from desk studies, interviews and workshops as reported in the comprehensive country reviews and compiled in CASRI Deliverable 2.1 (Maring et al., 2025). These comprehensive country reviews represent a wide variety

of European national and sub-national contexts. They collect, review and synthesise views on ES R&I needs and gaps, status of the science-policy-practice interface and funding opportunities.

Here we shortly recap the applied process to collect the underlying data used in this deliverable:

1. First, a desk study was performed with an aim to identify and summarise the relevant national ES R&I context (policies, main organisations and programs) existing R&I agendas, and existing funding programs in each country. Materials consisted of key documents and literature identified by the National Contacts (NCs) of the CASRI project. The desk study served as a basis for stakeholder interviews.
2. Secondly, each participating project partner identified around 20 national key stakeholders (NKS) to query on ES R&I knowledge needs around the predefined CASRI themes. The aim was to include informants from diverse backgrounds, such as public administration, research institutes, industries and business organisations, research and innovation funders, science communicators and other intermediate organisations, and selected NGOs. (A limited amount of) city-level informants were included as well since urban development was one of the preselected themes of the CASRI. Their contributions have subsequently been documented and mapped in terms of (1) knowledge type, (2) expected impact of decision level and (3) expected impact over time. However, there were gaps in representation, particularly from business. Focus was on national level, but three cases focused on sub-national context (Basque Country, Flanders, Wales). (see Maring et al., 2025). Results of the desk study and interviews were reported in interim national reports that were also used to assess the comparability between national results (e.g. level of elaboration) and if there was any need for remedial action e.g. to add specific information in a certain country / region.
3. Thirdly, national workshops were hosted to provide the interviewees an opportunity to reflect on the results from the desk study and interviews. Interim reports served as a material for the national workshops that provided the interviewees an opportunity to reflect the initial results and provide additional information. Not all interviewees participated in the workshops, and in some cases additional stakeholders and experts complemented those who were interviewed. The workshops aimed to review, synthesize and prioritize on a national level what would be reported to CASRI.

The results of this process were incorporated into a single document (D2.1, Maring et al., 2025). This document was internally reviewed by CASRI Core Group members and Theme Leaders as well as CASRI International Advisory Board. and selected key NKS The resulting final version is used as a material for the following analysis. Additional information is also sought from the interim national reports containing appendices that were not included to the final report. (e.g. full lists of funding opportunities).

The actual data used to compile the transnational commons perspective are the tables systematically collecting information from NKS (Maring et al., 2025). Each national report includes four tables organising data under the pre-defined CASRI themes. A fifth table allowed for including additional and cross cutting themes not covered in the predefined themes. Rows of the table were aimed to present information on proposed R&I priorities. Columns contained the following information:

- Column 1: Short description of the proposed R&I priority expressing why the proposed issue is urgent and/or important.

- Column 2: Type of knowledge need the proposed R&I contributes to. Three options were given (actionable, systemic, transversal, see Box 1.)
- Column 3: Description of the expected impact to be achieved by focusing on the priority. Time span of the impact was asked as well (short term < 10 years, long term >20 years).
- Column 4: Description of the geographical level for the expected impact (regional, national, European, international).

1.5 Methods

The specific aim of the underlying report on transnational shared common themes is to identify, prioritise and verify relevant themes and transnationally shared key issues for ES R&I, focusing on Europe. These aims are operationalized as follows:

- To identify: To structure the data coming from the national reviews, clustering has been applied to specific analytical frames. A first frame is to introduce a new level of thematic grouping that reflect the current political priorities. This grouping allows to deduct the societal relevance of the potential transnational commons. For this, the perceived public priorities as reported in DG COMMs (2025) European Barometer were consulted. The selection focuses on four distinct political priorities, described here as (1) security issues, (2) democracy and inclusive participation, (3) regulative efficiency and competitiveness, and (4) digitalisation including artificial intelligence (see also Table 2 for further definitional interpretation).

TABLE 2. CROSS-CUTTING THEMES AND EXAMPLES OF DESCRIPTIVE KEYWORDS

Themes	Descriptive keywords (examples)
Security	Scarcity, critical minerals, regenerative alternatives, dependency, independent, trade-offs, capacity
Democracy and Participation	Education, citizenship, resistance, social upheaval, gender vulnerabilities, attitudes, disadvantages populations, social disparities, equitable
Regulatory efficiency and Competitiveness	Markets, regulatory approaches, stable, finance practice, (policy) design, reform, innovation in governance
Digitalisation	Digital, AI, Industry 4.0, virtual
Other (No allocation)	

Another layer of clustering is introduced in which national research and innovation priorities are grouped into higher-level key issues. This required qualitative interpretations that were conducted under the four CASRI themes. The process has been documented by aligning the key issue with wordings from the original material as much as possible. Per pre-described CASRI theme the analysts have been given freedom to utilize additional codings and clustering levels if deemed relevant.

Together the thematic grouping creates a matrix of 4x4 representing political and societal challenges and opportunities (Figure 2). The resulting framework could capture all of the key issues identified from the data, while remaining open for new elements to be addressed.

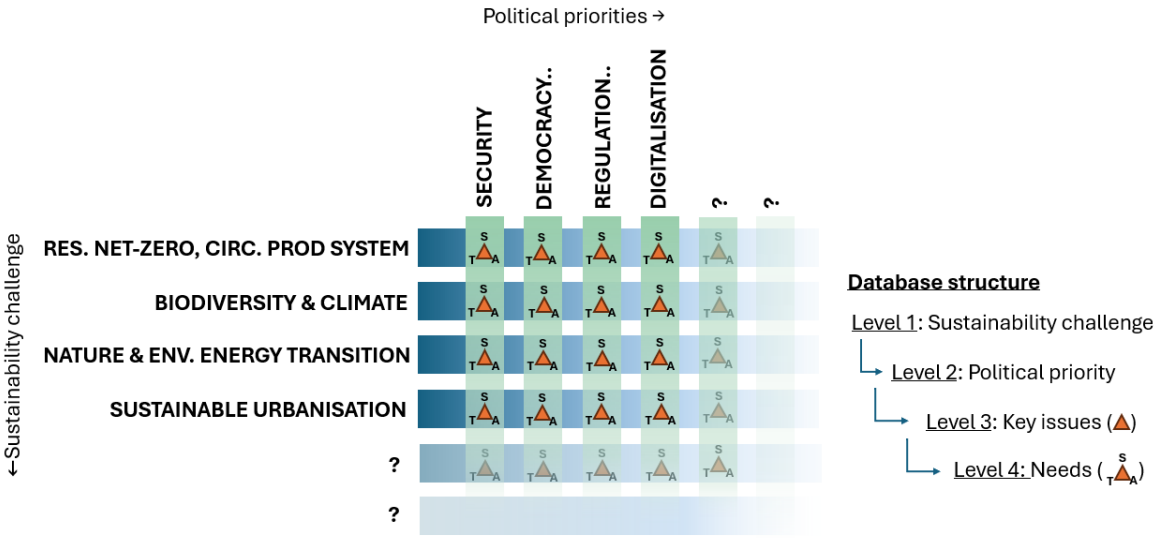


FIGURE 2. CONCEPTUAL FRAMEWORK GUIDING THE ANALYSIS

Note: Lines represent the predefined CASRI themes used to organises the data collection (see Table 1) and columns represent themes originating from the analysis of the data (see Table 2). Data comprises of research and innovation priorities addressing different knowledge needs (see Figure 1.)

- To prioritise: In order to converge from a very heterogeneous compilation of knowledge needs and R&I contexts to a consolidated transnational common perspective, two guiding principles have been applied:
    - The addressed key issues should have a transformative character, interpreted here as having a combination of articulated systemic, transversal and actionable needs (see Box 1). The characteristics of each underlying articulated knowledge need have been identified in the earlier phase during the comprehensive country reviews (Maring et al., 2025) and are simply clustered together in deducted key issues.
    - The addressed key issues need to be emphasized in multiple countries/regions across Europe. Key issues that do not resonate wider throughout Europe are prioritized lower, despite their possible national significance.

Via qualitative and quantitative interpretations, the underlying national data could provide a first initial assessment of which 'key issues' can be considered transnational and what knowledge needs are to be prioritised. Qualitative assessment involved visual inspection and deducting (fuzzy) patterns not directly documented in the data. Quantitative analysis involved counting instances and sorting to an order of importance using the guiding principles as described above.

- To verify: To supplement the national perspectives throughout Europe, a transnational stakeholder workshop has been utilized to reflect and assess on the compilation of national results. In this workshop up to 4 strategic NKS per CASRI country / region have been invited to join in on a 2-day discussion. The workshop monitored the balance across the participants' affiliations and expertise, attempting a blended representation of funders, knowledge producers and knowledge end-users to ensure a voice for systemic, transversal and actionable perspectives.

In the first day, results of the analysis were discussed in-depth in break-out sessions based on the CASRI themes. The discussion involved thorough reflections on the themes, the utilized 'political priorities', the identified 'key issues' and whether the addressed issues are to be encouraged, discouraged or supplemented in a dedicated EPA-driven research agenda. In a final round, every partaking stakeholder has been invited to indicate their top 3 priorities (using stickers) in the presented result of key issues and focus areas. The votes and discussions have provided indication of which issues are to be promoted or demoted on the initial assessment.

To deduct the strategic potential of a potential European collaboration, participants have been invited to reflect on the risks and opportunities under each considered political priority level using a world café setting, six groups had been distinguished, consisting of funders, researchers (natural sciences & technology), researchers (social sciences & humanities), ministries, knowledge users and environmental protection agencies, which rotated around the political priorities. All the acquired feedback has been recorded on the spot using post-its. .

2 Key themes and issues for ES R&I

This chapter summarises and identifies key ES R&I priorities presented by the comprehensive country reviews (CASRI D2.1, Maring et al., 2025). Sub-chapters are organised according the four preselected CASRI themes and an additional theme for other issues. Overarching summary is provided in the end of the chapter.

Sub-chapters summarise the CASRI themes and present both qualitative assessments and statistical summaries of priorities. Some of the overviews of key issues per contributing region are plotted to geographical maps. However, the maps should not be interpreted as country / region positions but as views of the selected NKS with affiliations in those regions.

2.1 Resilient, net-zero, circular production systems

For the CASRI theme 'resilient, net-zero circular production systems' D2.1 has delivered a total of 253 research priorities throughout 14 countries. 233 directly through interacting with NKS on the thematic focus, and 20 research priorities that have been obtained from thematic overlaps elsewhere.

2.1.1 Knowledge needs: addressed key issues

To structure the 253 research priorities we introduce the concept of 'key issues', for which we group and cluster the research priorities that aim at similar objectives. The allocation of research priorities is done manually and in one go, as to maintain consistency in qualitative interpretation. Key issues identified under the theme are summarised in Table 3, described with keywords and categorised under the four cross-cutting themes where possible.

TABLE 3. DESCRIPTIONS OF KEY ISSUES

Cross-cutting themes	Identified key issues	Words used in articulated knowledge needs
Security	Identified key issue	Words used in articulated knowledge needs
	S1 Security of resource supply	Bio-based, substitution, critical raw materials, secondary markets, trade-offs, recycling, critical minerals, alternatives, to replace, scarcity
	S2 Clean production	Eco-design, durability
	S3 Environmental Pollution	Waste management, hazardous chemicals, chemical-related risk, pollution
	S4 Climate Risk	Climate resilience, Urban resilience, shared environmental challenges
	S5 Water availability	Water resources, groundwater quality
	S6 Food security	Food security, sustainable agriculture
	S7 Soil and land management	Soil, spatial claim
	S8 Geopolitical tension	Geopolitical tension, conflicts, production patterns, geopolitical risk
	S9 Capital availability	Financial system, economy's capacity
	S10 Human capital availability	Skill gaps

Democracy and participation	P1 Regional potential	Jointly designed, local production, potential of regions
	P2 Coordination	Clarifying roles actors, agendas, enhance collaboration, coordination
	P3 Actor influence	Resistance, influence of actors, social upheavals, behaviour change
	P4 Equity	Equity, equitable distribution, benefit society,
	P5 Education	Awareness, information, education
Regulatory efficiency and Competitiveness	R1 Coordination	Intermediary organisations, governance of transformative processes, governance solutions, alignment of goals, strategy, connect actors
	R2 Regulatory system	Legal, contractual, confidentiality, integrity, institutional arrangement
	R3 Business model	Public support fund, finance solutions, unlocking markets, business model
	R4 Incentives	Incentives, green public procurement, economic practices, financial practice
Digitalisation	D1 Digital Twins	Simulate, AI support
	D2 Digital tools & efficiency	Logistics, automatic acquisition of information, productive, efficiency
	D3 Blockchain	Blockchain, information management
(Not allocated)	X1 Methodology	LCA, evaluation, (eco-)indicators, monitoring, metrics
	X2 Innovation	(all that was implying technology or new material development , TRL, scaling)
	X3 Integrative thinking	Quantitative modelling, bridging or compounding multiple challenges, developing integrated policies or metrics
	X4 Governance	(public) work programmes, implementation, tracing policy effectiveness
	X5 Societal responsibility	Higher human adaptability, responsibility, sustainable consumption, sufficiency
	X6 Research	Unknown-unknowns like micro-pollutants, negative emissions

In the first level of clustering around cross-cutting subthemes we find that the results have scattered around the CASRI partner regions in a variety of ways:

- **Security:** Overall the inquiry has yielded the greatest diversity of result under the thematic umbrella of ‘security’ (see also Fig. 3., plot a). The interpretation of security entails strategic security (geopolitical influence) but extents to a wider definition by also including strategic autonomy, availability of resources and specific vulnerabilities for regions (e.g. climate and pollution related risks) in its scope. Given how the stock take of knowledge needs has taken place in the time during the invasion of Ukraine, high energy prices and waning geopolitical stability (Draghi, 2024), a frequent reoccurring prioritised knowledge need relates to the ‘availability of resources’. For other key issues the spread is quite diverse, with no clear common pattern arising from the data.

- **Digitalisation:** Digitalisation, while articulated, is a relatively infrequently prioritised topic in relation to sustainable industrial transformation (see also Fig 3., plot b). Research needs are mostly expressed around the promise of resource and energy efficiency by improved automation, as well as new virtual technologies that could improve the tracking and tracing of components (e.g. block chain or digital twins).
- **Regulatory efficiency & competitiveness** Public-oriented innovations in institutional and regulatory systems are prioritised across the board throughout Europe (see also Fig 3., plot c). No specific pattern becomes visible in the data, although all knowledge needs address in one way or another the need for more coordinated action across the transformative challenges and the various actors and agencies involved (effort, resources). This entails clarity on the roles of actors and agencies, and an administrative system that supports modern and future processes and products (reform of current taxes and subsidies, decision making processes, business models).
- **Democracy & Participation** The articulation of public-oriented innovation around industrial ecosystems has occurred in a lower frequency (see also Fig 3., plot d). The influence of social actors and institutions is mentioned around Anglo-Celtic and Germanic speaking countries. These prioritized knowledge needs revolve around mediating driving and obstructive forces around equitable socio-technological change. Additionally, needs are expressed around clarifying and smoothening the roles of agents around entire value chains.

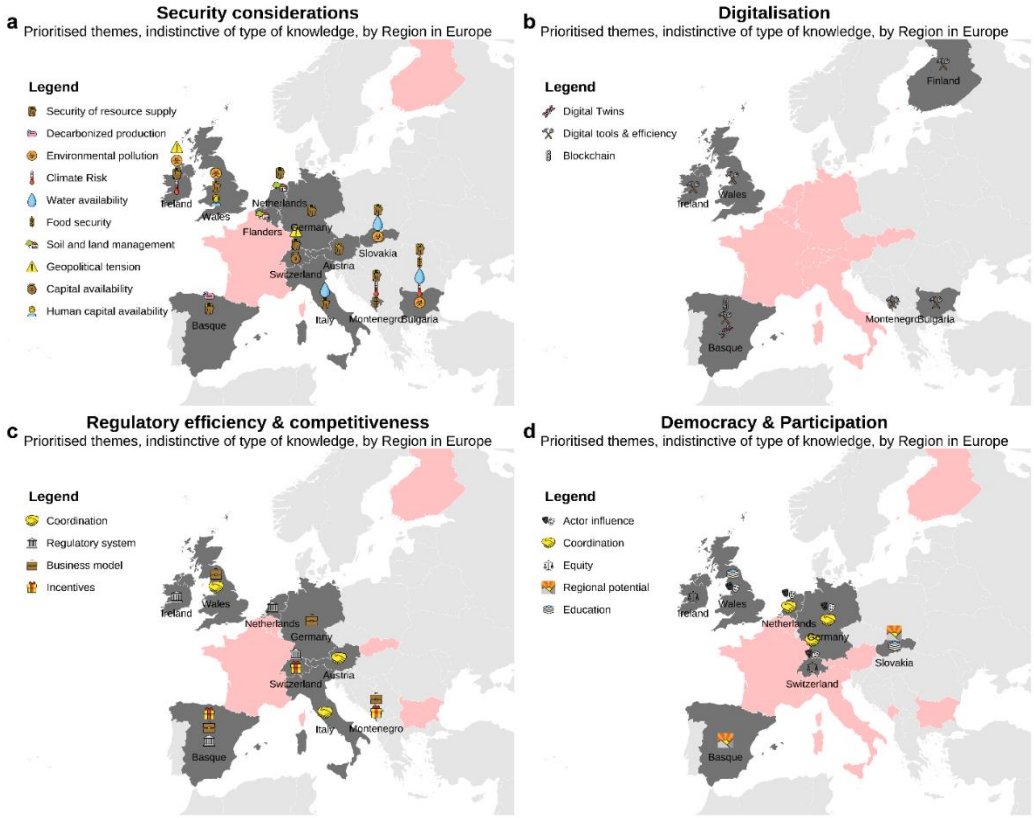


FIGURE 3 - OVERVIEW OF INDICATED KNOWLEDGE NEEDS PER REGION AND SUBTHEMES

Note: red shaded areas indicate an absence of prioritized knowledge needs in that category and region.

- **Other:** other knowledge needs have been expressed that did not fit the predefined political priorities. These needs could be grouped under more traditional R&I objectives or traditional to the task field of the local environmental protection agencies (EPA) (see Fig. 3).
    - Traditional R&I objectives: Multiple knowledge needs were expressed around promoting, testing or utilizing new, more efficient or alternative production technologies in various industrial value chains (such as metals, forestry, industrial carbon capture and storage, hydrogen, waste, additive industry, agriculture or chemicals).
    - Traditional task field EPAs: On more environmental oriented public innovation level, needs focused on the amalgamation of various policy challenges and the need to develop integrated knowledge that can bridge the gap between the various objectives and decision levels involved. Further, methodological development had been coined second, indicating needs around broadly accepted tools and processes and actionable metrics and indicators of progress to be used in decision making.
    - Wider public R&I need: In more sporadic cases some knowledge needs had been expressed about public, personal and private responsibility, mostly related to sufficiency and consumption ('societal responsibility').

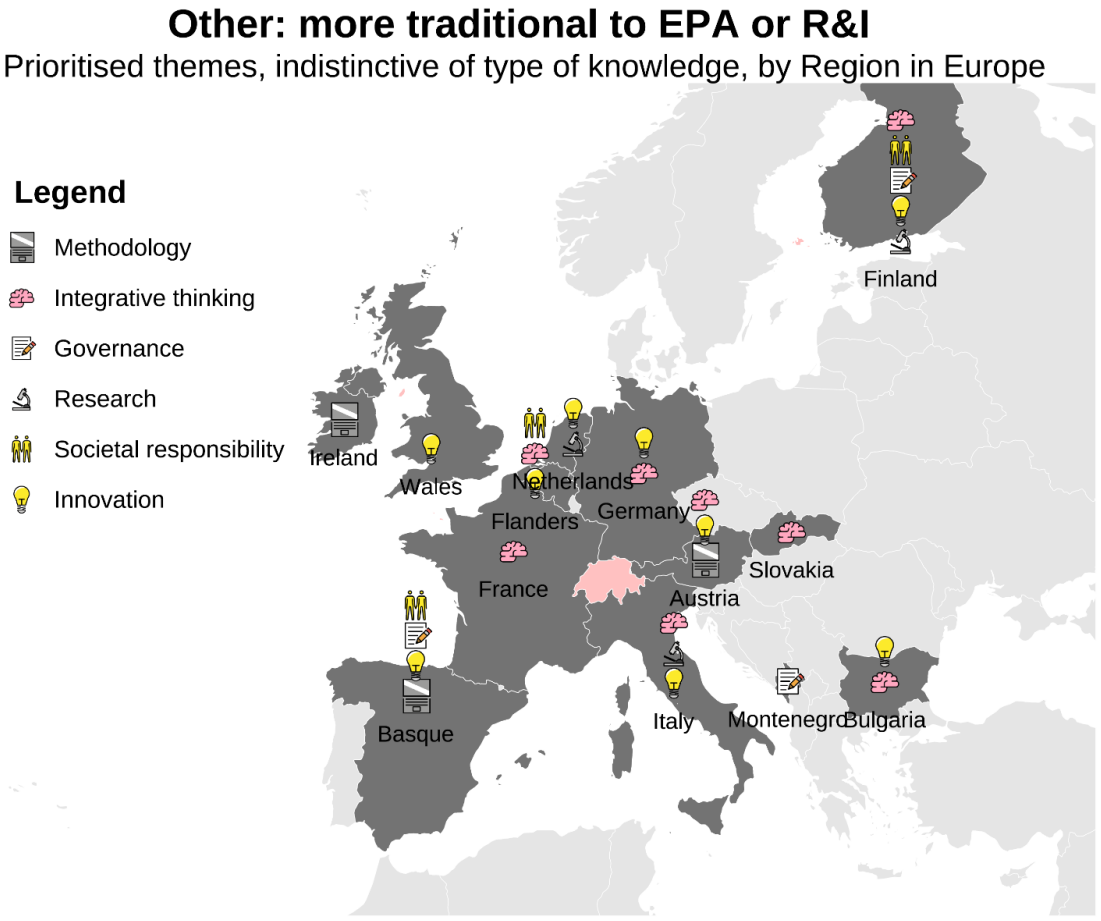


FIGURE 4. OVERVIEW OF INDICATED KNOWLEDGE NEEDS PER REGION IN THE 'OTHER' CATEGORY
Note: red shaded areas indicate an absence of prioritized knowledge needs in that category and region.

2.1.2 Extracting transnational commons

Despite the contextual differences across countries, resulting in a wide array of knowledge needs and anticipated effects across space and time, we define the transnational common as the topic in which the largest majority of CASRI regions have contributed to. By ignoring the regional dimension and compounding all the knowledge need contributions per implied key issue, an overall impression can be drawn on which key issues contain the biggest 'need' along various crosscutting dimensions. We develop a ranking method by defining the following rules:

- To focus on transnational commons, we remove the contributions that only indicated a regional (R), national (N) or combination of (de)centralized (R, N) impact of the expressed knowledge needs. This removed 63 contributions from the total list.
- CASRI is mostly interested in cross-cutting contributions. As a result, contributions that have addressed systemic, transversal and actionable needs in conjunction with each other get priority. Ranking is decided on which contribution has greater numbers of countries contributing to it.
- To more carefully consider where in the knowledge ecosystem a knowledge need is expressed we specify the result with two more characteristics, which is the (1) mode of knowledge need (distinguishing between technocratic or reflective knowledge production needs, for which we follow the notation of Mode 1 and Mode 2 as introduced by Gibbons et al. (1994)[1]) and the (2) knowledge ecosystem in which it resides (here reduced to industrial innovation ecosystem or wider systemic knowledge ecosystem)

From Figure 55 it becomes clear that the bulk of expressed knowledge needs are centred around 10 Key issues (until rank 10), accumulating about 50% of all the contributions obtained across Europe. The applied method does not guarantee internal consistency for the underlaying priorities per key issue and requires further articulation of a common problem and solving logic.

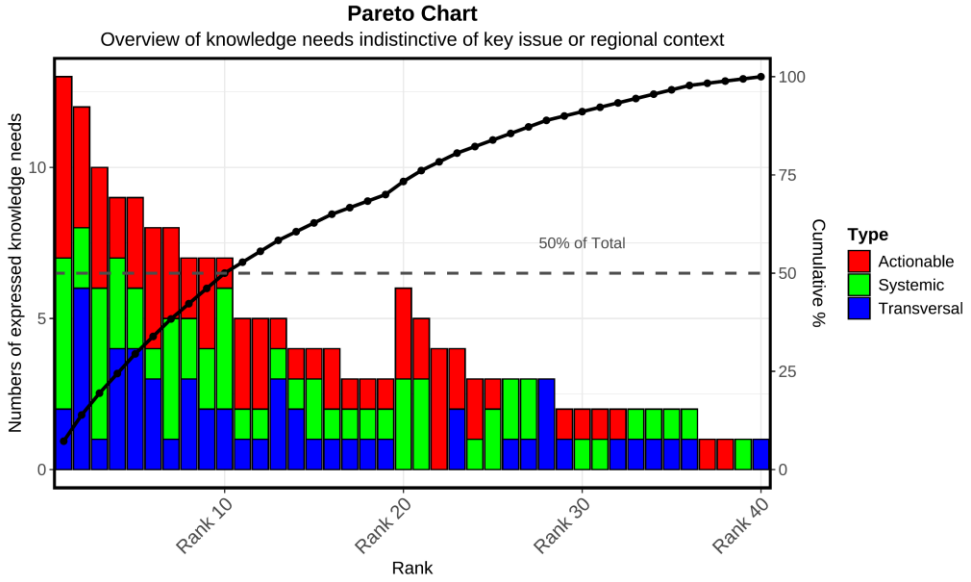


FIGURE 5. PARETO CHART OF KNOWLEDGE NEEDS PRIORITISING ON THE GREATER COMBINATIONS OF KNOWLEDGE TYPES PER KEY ISSUE

[1] We loosely apply this framework to make a distinction between more technocratic and reflexive or participatory needs. The framework itself has evolved over time and variations in literature exist. For simplicity we maintain a single and binary notation although its application may be wider than its original definition.

From Figure 6, we can observe that the majority of the articulated knowledge needs are implying more traditional forms of inquiry, documentation and utilization (Mode 1). Given also their aim towards either more industrial specific ecosystems or more system-wide ecosystems, the articulated knowledge needs can loosely be interpreted as extensions of respectively existing Science & Technology innovation policy (competitiveness oriented) or more Mission-oriented innovation policies (competitiveness oriented within specific conditions) implemented across Europe. Knowledge needs more off-the-beaten-track are more presented on the right-hand side of Figure 5 – implying the need for more co-creative and participatory approaches of knowledge development. Only system-wide knowledge needs are articulated. It is unknown if the absence of more industry ecosystem oriented knowledge systems is deliberate or a gap in the data collection.

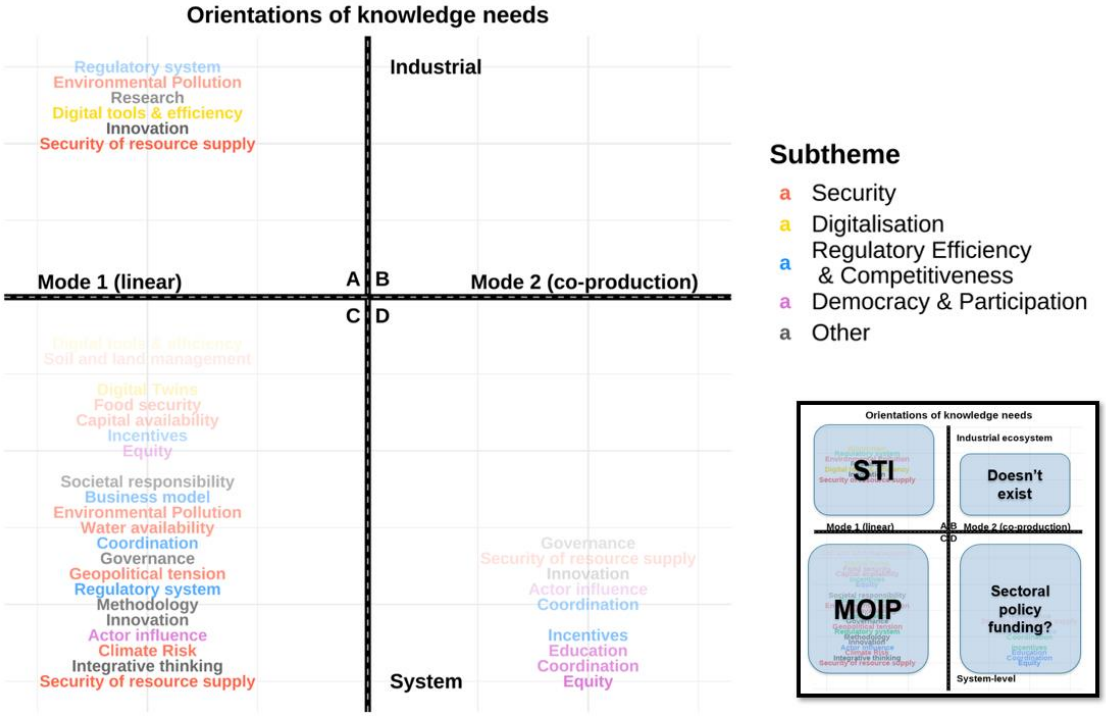


FIGURE 6. QUADRANT OF KNOWLEDGE NEEDS

Note: Quadrants of knowledge needs indicating knowledge ecosystem (y-axis) and knowledge mode (x-axis). high visibility means high ranking, low visibility means low ranking. the smaller panel indicates in which quadrant more specific R&I funding and policy objectives are expected, with sti referring to 'science and technology innovation policy" objectives, MOIP referring to "mission-oriented innovation policy" objectives.

Zooming in on the results of the ranking we find that traditional R&I objectives are still considered the primary field of knowledge needs, as seen through the high ranking of industrial ecosystem oriented questions (Type 'Industrial', and Key issue 'Innovation'). 'Security of resource supply' is a multiple times addressed Key issue, particularly in terms of fuel and feedstock, followed by more wider public innovation oriented Key issues related to *Democracy & Participation* and more *Other* traditional EPA task area needs. The pattern repeats itself more or less throughout ranking 6 to 10 although placing greater emphasis on a wider societal scope.

The ranking is broadly robust:

- Local scale: allowing (de)centralized oriented knowledge needs to be part of the sample only shifts *Other* 'Innovation' and *Digitalisation at* the Industrial level upward while maintaining the order of other Key issues. Generally *Regulatory efficiency & Competitiveness* Key issues are ranked lower, implying lower frequency of verbalised needs on elements like facilitating and streamlining. Other *Security* related challenges have been reported more sporadically and therefore rank lower.
- Short or long term impact: placing greater weight on either short-to-medium term or medium-to-long term impacts decides whether the first half or lower half of

- Table 4 gets more prominence. Counter-intuitively the short-to-medium term knowledge needs position wider system innovation more prominently, putting ‘ Security of resource supply’ top, and including two new Key issues (*Democracy & Participation* ‘Education’, and *Regulatory efficiency & Competitiveness* ‘Coordination’). The medium-to-longer term lifts exclusively knowledge needs oriented at industrial ecosystem and innovation to the top of the ranking (including *Other* ‘Research’ on negative emissions).

TABLE 4. RANKED KEY ISSUES INDISTINCTIVE OF REGIONAL CONTEXT

Rank	Political priority	Mode	Eco-system	Key issue	Focus
1	Security	Mode 1	Industrial	Security of resource supply	F1 Diversification of fuelling, feedstock or sourcing
					F2 Regenerative (bio-)economy
					F3 Resilience and shock prevention
2	Security	Mode 1	System	Security of resource supply	F4 Deducting critical resource needs
					F5 Facilitating circular economy
3	Other	Mode 1	Industrial	Innovation	F6 Efficiency and efficient utilization
					F7 Electrification and diversification need
					F8 New products and materials
					F9 New technologies and processes
4	Democracy & Participation	Mode 2	System	Equity	F10 Economic systems
					F11 Social systems
5	Other	Mode 1	System	Integrative thinking	F12 Competences and capabilities
					F13 Risks and longer term thinking and planning
6	Digitalisation	Mode 1	Industrial	Digital tools & efficiency	F14 Efficient processes
					F15 Improved information systems
7	Security	Mode 1	System	Climate Risk	F16 Climate adaptation
					F17 Cross-border coordination
					F18 Ecological risks
8	Democracy & Participation	Mode 1	System	Actor influence	F19 Strategic behaviour of individual actors
					F20 Strategic behaviour of political or institutional actors
					F21 Introducing new approaches
9	Other	Mode 1	System	Innovation	F22 Negative emissions
					F23 Safe and Sustainable by Design
10	Other	Mode 1	System	Methodology	F24 Competences and capabilities
					F25 Monitor systems
11	Democracy & Participation	Mode 2	System	Coordination	F26 Clarifying responsibilities
					F27 Integrative policy design and agenda-setting
12	Regulatory Efficiency & Competitiveness	Mode 1	System	Regulatory system	F28 Competences and capabilities
					F29 Integrative policy design and agenda-setting
13	Security	Mode 1	System	Geopolitical tension	F30 Competences and capabilities
					F31 Resilience and shock prevention
14	Democracy & Participation	Mode 2	System	Education	F32 Introducing new understandings
15	Other	Mode 1	System	Governance	F33 Introducing new approaches
					F34 NA

TABLE 5. RANKED KEY ISSUES INDISTINCTIVE OF REGIONAL CONTEXT

Rank	Political priority	Mode	Eco-system	Key issue	Focus
16	Other	Mode 1	Industrial	Research	F35 Negative emissions
17	Regulatory Efficiency & Competitiveness	Mode 1	System	Coordination	F36 Clarifying responsibilities
					F37 Competences and capabilities
18	Security	Mode 1	System	Water availability	F38 Efficiency and efficient utilization
					F39 Risks and longer term thinking and planning
19	Security	Mode 1	Industrial	Environmental Pollution	F40 Efficiency and efficient utilization
					F41 Risks and longer term thinking and planning
20	Security	Mode 1	System	Environmental Pollution	F42 Risks and longer term thinking and planning
21	Regulatory Efficiency & Competitiveness	Mode 2	System	Incentives	F43 Economic systems
					F44 Resilience and shock prevention
22	Other	Mode 2	System	Miscellaneous	F45 Economic systems
					F46 Introducing new approaches
					F47 Resilience and shock prevention
					F48 Scaling
23	Regulatory Efficiency & Competitiveness	Mode 1	System	Business model	F49 Introducing new approaches
24	Other	Mode 1	System	Societal responsibility	F50 Deducting critical resource needs
					F51 Introducing new approaches
25	Other	Mode 1	System	Miscellaneous	F52 Capacity building
					F53 Economic systems
					F54 Efficiency and efficient utilization
					F55 Strategic behaviour of individual actors
					F56 Strategic behaviour of political or institutional actors
26	Democracy & Participation	Mode 1	System	Equity	F57 Equity
					F58 Introducing new understandings
27	Regulatory Efficiency & Competitiveness	Mode 2	System	Coordination	F59 Efficiency and efficient utilization
28	Regulatory Efficiency & Competitiveness	Mode 1	Industrial	Regulatory system	F60 Safe and Sustainable by Design
29	Digitalisation	Mode 1	Industrial	Blockchain	F61 Tracking and tracing

TABLE 6. RANKED KEY ISSUES INDISTINCTIVE OF REGIONAL CONTEXT

Rank	Political priority	Mode	Eco-system	Key issue	Focus
30	Regulatory Efficiency & Competitiveness	Mode 1	System	Incentives	F62 Competences and capabilities
					F63 Introducing new approaches
31	Security	Mode 1	System	Capital availability	F64 Economic systems
32	Security	Mode 1	System	Food security	F65 Resilience and shock prevention
33	Democracy & Participation	Mode 2	System	Actor influence	F66 Strategic behaviour of individual actors
34	Digitalisation	Mode 1	System	Digital Twins	F67 Information systems
35	Other	Mode 2	System	Innovation	F68 Capacity building
36	Security	Mode 2	System	Security of resource supply	F69 Integrative policy design and agenda-setting
37	Other	Mode 2	System	Governance	F70 Strategic behaviour of individual actors
38	Security	Mode 1	System	Miscellaneous	F71 Risks and longer term thinking and planning
39	Security	Mode 1	System	Soil and land management	F72 Deducting critical resource needs
					F73 Risks and longer term thinking and planning
40	Digitalisation	Mode 1	System	Digital tools & efficiency	F74 Efficiency and efficient utilization

Note: Top 10 has been deducted based on the presence of the full collection of knowledge needs in the data and across the greatest diversity of contribution regions. The column 'Focus' provides further information on the addressed knowledge gap.

2.2 Biodiversity and Climate

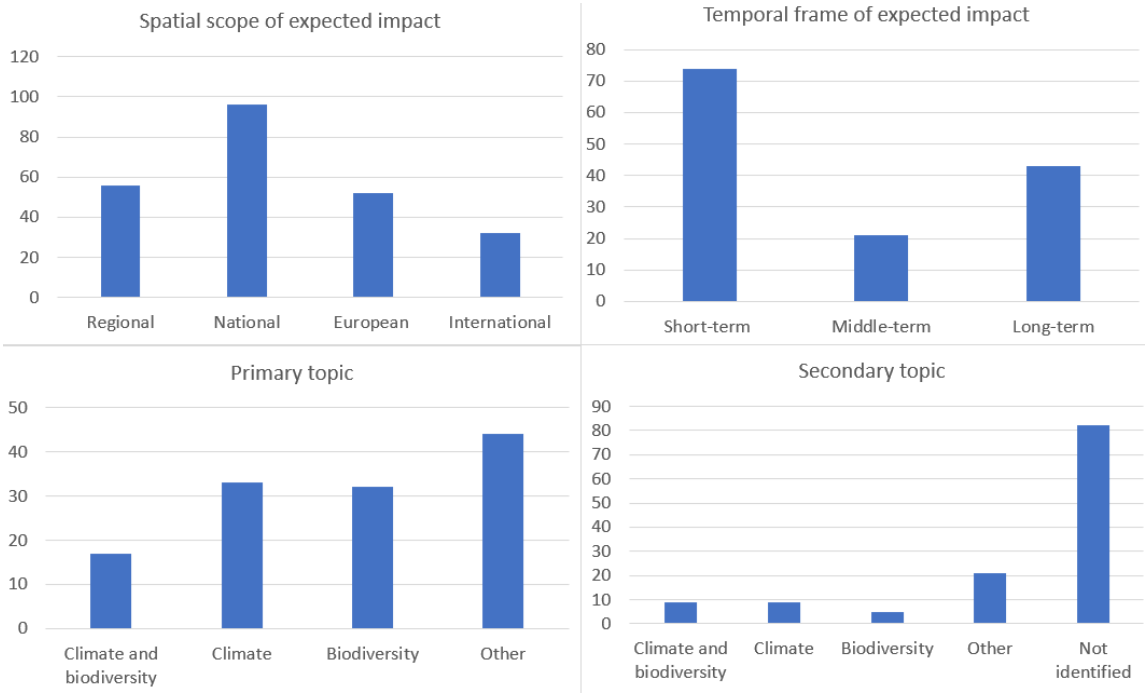
2.2.1 Overall characterisation of the theme

Altogether, 126 individual R&I priorities were identified and proposed under the theme Biodiversity and Climate. The number of proposed priorities per country varied from 3 to 17. Figure 7 presents the distribution of all the priorities proposed under the theme. Five countries provided additional information or further explanatory text besides the tables presenting the priorities (see Maring et al., 2025). This information, as well as descriptions of the country contexts presented in D2.1. were used to support the interpretations and qualitative analysis of the material.

There were some overlaps between the CASRI-themes. The most notable overlap was related to the R&I priorities addressing the need to reduce greenhouse gas emissions that relate both to climate change and energy transition themes. For example, in Irish case priorities "Climate Action: Bringing Mitigation and Adaptation Together" and "Developing climate neutral pathways for Ireland" were proposed under the CASRI-theme "Nature & environmentally friendly energy transition". Similar priorities were proposed also under the CASRI-theme "Climate and biodiversity". Under the theme Biodiversity and climate the original categorisations as proposed by the respondents are followed since all of the proposed priorities were found relevant for the theme.

Knowledge types

FIGURE 7. OVERVIEW OF THE PRIORITIES PROPOSED UNDER THE THEME BIODIVERSITY AND CLIMATE



Different knowledge types were often mentioned together. Most priorities were considered as issues contributing to two or three knowledge types. All three knowledge types were assigned to 19 priorities and two knowledge types for 48 priorities while 44 priorities were characterised with a single knowledge type. “Actionable” knowledge was the sole focus of 26 priorities while 14 priorities focused on “Systemic” Knowledge. Even though “Transversal” knowledge was often mentioned together with “Systemic” or “Actionable” knowledge, only four of the proposed priorities focused only on transversal knowledge.

However, making interpretations from the data was challenging. Typically, no explanations stating why certain categories were assigned to certain priority were available. Sometimes it was difficult to interpret why certain knowledge type was (or was not) mentioned. It is also possible that the respondents did not comprehend the terms “Actionable”, “Systemic”, and “Transversal” in a coherent way. Therefore, the data on knowledge types should be considered as indicative.

Temporal scope of impacts

The respondents were asked to indicate the temporal scope of the expected societal impact of the proposed priority. The options given were short-term impact (realised in less than 10 years) and long-term impacts (realised over a period longer than 20 years). Some respondents also added a middle term (10 to 20 years) to the original categorisation (for 21 priorities). Estimation of the temporal scope of impacts turned out as challenging. This was partly because the impacts were often vaguely described, and they involve considerable uncertainties as well as delayed or indirect effects making it difficult to estimate the timescale of their full realisation. Many priorities also involved different kinds of potential impacts that can have different timescales: 35 priorities were considered to have both short and long-term effects while no estimation of temporal scope of impacts was provided for 26 priorities.

Spatial focus of the priorities

A characterisation of the spatial focus of each proposed R&I priority was asked. Most of the priorities were considered relevant over more than one of spatial scale. National scale was most often mentioned (76.2% of cases). This was expected since the data was collected focusing on national settings. Regional (sub-national) level (44.4%) was mentioned about as often as European level (41.3%). Over a quarter (27.0%) of the cases mentioned international or global level, highlighting research needs beyond the European scope. The proposed national-level priorities often have implications also beyond national scale. There were some challenges in identifying the spatial scale. In some cases, regional was understood as supra-national level. In other cases, focus was on sub-national or local level effects and knowledge needs.

2.2.2 Key issues identified

As described below, relatively few of the priorities suggested under the theme focused both on biodiversity and climate, while others focused only on climate or biodiversity. A considerable number of priorities addressed biodiversity or climate only weakly or indirectly and focused on other issues. The priorities did not present a focused and consistent theme. Therefore, systematic ranking all of the priorities proposed under the theme was not meaningful. Instead, priorities are grouped to subthemes according to their main focus, and key issues combining individual priorities into larger units are identified under each subtheme.

Focus of the proposed priorities

The main focus (integrated focus on both climate and biodiversity, climate only, biodiversity only, other issues) and was identified from each of the proposed research priority. Despite the overall thematic framing highlighting the connections between climate change and biodiversity, only 13.5% of the proposed priorities focused on this intersection, i.e. addressed both biodiversity and climate issues. Table 5 presents the key issues focusing on the intersection of climate and biodiversity. Impacts of changing climate to biodiversity and ecosystems were emphasised, whereas impacts of biodiversity change on climate received little attention. Solution-oriented perspective was emphasised, with concepts such as nature-based solutions, regenerative agroforestry and resilience.

Identification and management of ecological and social vulnerabilities related to combined risks from climate change and biodiversity loss was noted both related to mountain ecosystems and urban greening. Producing new knowledge helping to understand key interdependencies between climate change and biodiversity loss was noted. Research needs related to effective utilisation of data and integrative knowledge generation was emphasised. Inclusive awareness-building and generation of comprehensive, future-oriented and policy-relevant knowledge was also addressed.

TABLE 7. KEY ISSUES INTEGRATING BIODIVERSITY AND CLIMATE

Key issues integrating biodiversity and climate	Description / keywords	Connections with political priorities
D1 Data utilisation: Integrative monitoring and inclusive assessment of climate change and biodiversity	BC 1 Innovative monitoring methods and enhanced use of spatial data on ecosystems, soil and water; biodiversity effects of climate change BC2 Identification of interconnected risks, cascading effects and thresholds BC3 Climate and biodiversity awareness creation, education and participation (e.g. land use issues)	**Digitalisation** (Security; Participation and democracy)
R1 Governing the interaction: impacts of climate policy and biodiversity decline	BC4 Identification of biodiversity impacts of climate change and climate policies, focusing on key sectors or ecosystems BC5 Building socio-ecological resilience through climate adaptation, nature-based solutions, green infra BC6 Management of synergies and trade-offs between climate adaptation and biodiversity conservation BC7 Development of regenerative agro-forestry practices, landscape revitalisation, habitat creation	**Regulatory efficiency and competitiveness** (Security)
R2 Regulative and institutional settings for policy implementation	BC8 Mechanisms for wider, rapid and effective implementation of solutions, barriers to action BC9 Integrated transnational collaboration mechanisms and practices BC10 Means and impacts of mainstreaming climate and biodiversity policies	**Regulatory efficiency and competitiveness** (Participation and democracy)

About a quarter (26.2%) of the proposed priorities focused mainly on the climate change or climate policies (Table 6). Issues related to climate adaptation were emphasised over climate mitigation. For example, research need emphasised the relationship between preventing climate disasters and building resilience against them. Knowledge needs related to social sciences, climate policies and regulations were emphasised, potentially indicating the already strong natural science-based climate research. Generation and use of climate metrics and indicators was requested.

TABLE 8. KEY ISSUES FOCUSING ON CLIMATE

Key issues focusing on climate change	Description / keywords	Connections with political priorities
X1 Identification of the effects of climate change and climate policy	C1 Long-term structural effects of climate change and climate policy (e.g. demographics) C2 Effects of climate policy and decarbonisation in different sectors, such as agriculture, forestry, fisheries C3 Effects of climate change on different ecosystems and sectors, such as healthcare, water resources, agriculture, forestry	**Other** (Regulatory efficiency and competitiveness)

TABLE 9. KEY ISSUES FOCUSING ON CLIMATE - CONTINUED

Key issues focusing on climate change	Description / keywords	Connections with political priorities
R3 Effective climate policy: Regulative settings and policy implementation	C4 Developing comprehensive and applicable national long-term paths to climate neutrality C5 National and international implementation of science-based climate policies, including economic instruments and finance C5 Management of synergies and conflicts between climate mitigation and adaptation, ecosystem-based mitigation, cross-sectoral climate governance C6 Justness of climate adaptation, preparedness and resilience across different scales	**Regulatory efficiency and competitiveness** (Participation and democracy)
D2 Data-driven knowledge: Generation of climate data, modelling and scenarios	C7 Systematic data generation and indicators, utilisation of spatial data, improved modelling, AI-based applications, digital twins, decision support C8 Early warning systems and climate risk management C9 Consistent and effective use of climate data across sectors and policies, awareness raising C10 Citizen science on climate issues, understanding human behaviour, building consensus	**Digitalisation** (Security: Participation and democracy)

A quarter (25.4%) of the proposed priorities focused primarily on biodiversity (Table 7). Issues related to the need for better basic understanding and monitoring of biodiversity change were emphasised.

TABLE 10. KEY ISSUES FOCUSING ON BIODIVERSITY

Key issues focusing on biodiversity	Description / keywords	Connections with political priorities
D3 Ecosystem monitoring: Understanding biodiversity change	B1 More comprehensive, coherent, up-to-date, policy-relevant biodiversity monitoring, use of spatial data B2 Monitoring and management of invasive species B3 Aquatic biodiversity and management of water ecosystems B4 Genetic diversity, soil biodiversity in natural and managed lands	**Digitalisation** Regulatory efficiency and competitiveness
R4 Biodiversity management: Valuation and incentives for action	B5 Ecosystem accounting making the value of biodiversity change visible to policy, markets and firms B6 Creation of collaborative participation and context-sensitive awareness building, connecting people with nature B7 Ecosystem management through rewilding, restoration, reforestation, or ecosystem connectivity, human-wildlife co-existence B8 Sector-specific actions: Nature-friendly tourism, agriculture, forest ecosystem management	**Regulatory efficiency and competitiveness**
S1 Threats to biodiversity; Driving forces and hotspots	B9 Drivers behind biodiversity decline B10 Decline of pollinators B11 Pollution and chemical risks on biodiversity	**Security** (Participation and democracy)

Interestingly, the largest share of (34.9%) proposed R&I priorities focused mainly on other issues such as advanced water management strategies or integrating climate resilience and soil protection criteria into key territorial instruments (Table 8). They addressed climate or biodiversity as a secondary issue or completely focused on other issues such as water or forestry. Challenges related to measurement and assessment methodologies of environmental change were highlighted. Use-inspired transdisciplinary research and co-construction with various actors were called for to enhance utilisation of knowledge. A potential tension between locally relevant knowledge production and requests for contributions relevant for international policy and EU instances could be noted.

TABLE 11. KEY ISSUES FOCUSING ON OTHER ISSUES

Key issues focusing on issues beyond biodiversity or climate	Description / keywords	Connections with political priorities
D4 Effective sustainability monitoring and data integration	OCB1 Cost-effective, comprehensive and impactful monitoring and decision support integrating different spatial scales and sectors (e.g. land use, soil health, hydrology) OCB2 Improving public awareness of impacts of plans and decisions OCB3 Better utilisation of spatial data and remote sensing OCB4 Transdisciplinary participation and inclusive collaboration e.g. land use management, renewable energy projects	**Digitalisation** (Participation and democracy)
R5 Cross-sectoral integration: activities across scales and sectors	OCB5 Nature and well-being economy, incentives and de-incentives for action, harmful subsidies OCB6 Paths to transformation: User-inspired experiments, sustainability demonstrations, education OCB7 Transnational implementation of environmental measures OCB8 Mainstreaming biodiversity or climate actions to other sectors such as finance, energy, infrastructure	**Regulatory efficiency and competitiveness**
X2 Other issues related to climate or biodiversity	OCB9 Impacts of environmental pressures on health, e.g. antimicrobial resistance OCB10 Ecological and social impacts of ocean acidification OCB11 Integrated water resource management in changing climate, water quality and quantity, water system restoration, water policy	**Other** (Security)

Figure 8. illustrates the variation of different topics under different cross-cutting themes according to geographical areas. Maps are based on keywords assigned to the suggested R&I priorities and provide only indicative overviews. Maps should not be interpreted as country or region positions but views of experts from respective areas.

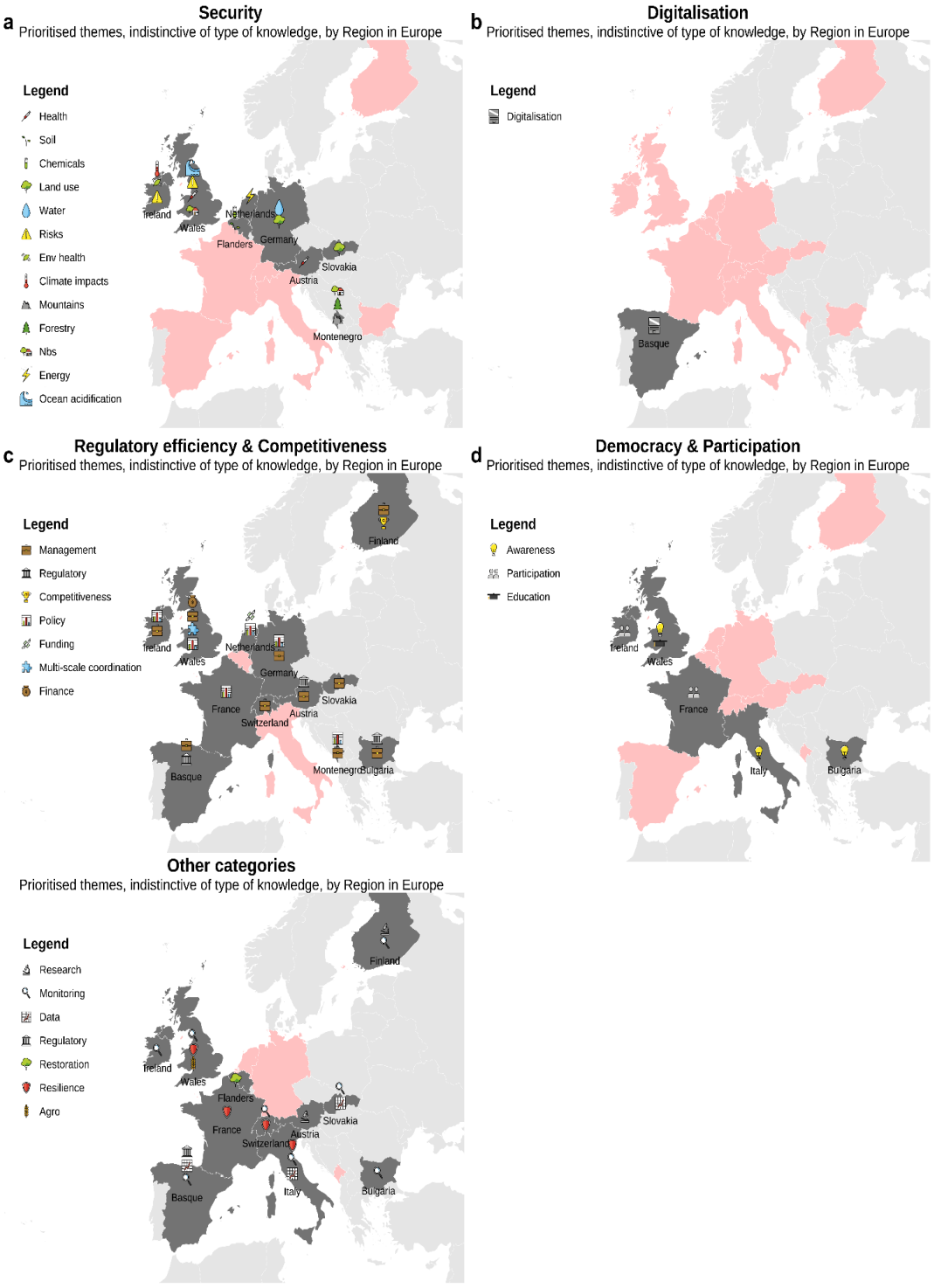


FIGURE 8. INDICATIVE TOPICS UNDER CROSS-CUTTING THEMES

2.2.3 Reflection: insights from the key issues

Governing systemic changes

Transformational change of systems was as underlying assumption for that could be identified as a common motivation for the priorities. Need for transformation was evident especially in priorities focusing on long-term management needs and impacts. Awareness raising and transformative, innovative and transdisciplinary education were emphasised. There is a need to equip learners with the skills to address complex global challenges. Such awareness and education foster interdisciplinary collaboration, enhance innovativeness and empower citizens to challenge disinformation and misinformation.

Mainstreaming of biodiversity concerns into other systems such as energy, finance and infrastructure long-term opportunity was considered a long-term opportunity to minimise ecosystem impacts and secure ecosystem services. Likewise, mainstreaming of climate concerns was emphasised, both in general terms and in more specified cases such as integration of science-based climate resilience and soil protection criteria in relevant economic instruments such as the principle of “do no significant harm” or green taxation.

Monitoring

Local gaps in environmental monitoring were mentioned and ensuring the coherence of monitoring was raised up as a key issue both related to climate and biodiversity. Possibilities for more integrated climate and biodiversity monitoring received relatively little attention. Development needs of monitoring included ensuring the compatibility of different data sources and improving the integration of different levels of climate or biodiversity monitoring separately. In addition to data production, possibilities improved use of monitoring data were emphasised. For example, the orderly feeding of regional data into European and global models would facilitate coherent decision-making related to issues such as river flood risk analysis.

Data processing and management, artificial intelligence

Machine learning (ML) applications and artificial intelligence (AI) were only rarely mentioned directly. Examples include R&I priorities highlighting the potential of AI applications to track changes in biodiversity identify threatened areas, address spatial planning needs quickly and helping implement effective conservation strategies efficiently (Basque country, Italy). Despite the relatively few direct mentions of AI, however, the importance of more advanced capabilities to collect, analyse and utilise large dataset on climate and biodiversity was a clear underlying issue: “data capitalisation” was specifically called for. Short-term impacts were here emphasised, as the suggested priorities typically highlighted potential for relatively rapid benefits from improved data processing. For example, better utilisation of spatial data, especially satellite images and other remote sensing data was raised as a possibility for short-term sustainability benefits.

Different priorities related to data were recognised, both arising from the specific needs of climate or biodiversity research and more general opportunities of new technologies. An example of the former were the calls for improved modelling to better understand climate and ecosystem change and different management options. An example of the latter was the call for building digital territorial twins to help to anticipate and manage climate risks. Digital twins are virtual representations designed to accurately reflect a structure and behaviour of physical object or system. Building and operating them requires extensive data collection and highly developed information processing capabilities.

Even in cases where AI was not specifically mentioned, the proposed R&I priorities indirectly address several ways in which AI can contribute towards achieving climate and biodiversity goals. For example, AI can be used to improve data processing of biodiversity loss and habitat destruction by analysing satellite imagery for deforestation patterns. It can enhance the predictive power in modelling long-term climate and short-term weather events, allowing better disaster management. AI may make it possible to develop integrative decision support systems combining all relevant components of sustainable development into a single management system based on scientific principles.

The priorities indicate a high diversity of potential uses of advanced information technologies such as AI applications and highlight the need for concerted efforts to integrate such technologies into existing systems across sectors and different levels of governance. This also includes collaboration between governments, private enterprises, NGOs, and educational and research institutions. Legal, security or ethical considerations were not raised up as a top priority, leaving issues such as fair use of data, data privacy concerns or biases created by algorithmic debate and large language models with little attention.

Participatory governance and inclusiveness

If considered from this perspective, the proposed priorities can be divided in two general groups. A larger one focused on needs to strengthen or integrate existing knowledge and governance structures. For example, strengthening of global climate diplomacy and integration of biodiversity knowledge production and global biodiversity governance with European chemicals regulations were called for. The second, smaller group focused on needs to develop new kinds of structures and practices aimed to address challenges of participation and just transition where democratic participation is actively supported at all levels. This also emphasizes the importance of transparent governance structures fostering civic engagement among different demographics.

Related to climate action, the need to build governance based on consensus was mentioned. Consensus-seeking governance was seen as vital for a just transition, ensuring inclusive decision-making that empowers all levels of society. Empowering citizens through openness and accountability mechanisms fosters equitable solutions, strengthens collaboration, and accelerates the shift to a sustainable and resilient future. Governance and adaptive management turning societal conflicts into synergies in sectors such as agriculture and forestry options emerged as one key challenge. For example, innovative agricultural practices to conserve biodiversity and ensure food security whilst reducing nutrient emissions were called for. Such innovations should be developed in partnership with key actors, without disenfranchising farmers and wider society.

Regulatory efficiency and competitiveness

Gaining competitive advantages through innovation was an underlying issue, related to issues such as new energy solutions and regenerative agriculture and forestry. Another underlying issue was that advanced environmental monitoring contributes to reduced risks and allows considerable economic savings in the long term. Internationally harmonised and effective regulation can also support investments in sustainable technologies and innovations. Economic competitiveness was not a distinctive element considered under the theme. Instead, competitiveness was considered mainly from the perspective of regulatory effectiveness. Consistently adopting best practices for environmental governance was emphasised. Reducing bureaucratic hurdles in implementing climate or biodiversity projects can also improve accessibility for various market players.

The need to review environmentally harmful subsidies and other financial incentives and developing effective policies to financially de-incentivise was noted as an important yet particularly challenging research need.

A need for international collaboration on developing coherent environmental treaties and regulations, facilitating fair trade practices globally was recognised. Global level governance mechanisms developed under climate and biodiversity policies provide a potential case for studying evolution of international negotiations, law and governance and potential for applications to other topics. For example, lessons about effective or non-effective use of expertise, arguments and indicators can help to improve regulatory effectiveness and environmental management.

Summary

Overall, the theme was characterised by a high variety of different issues, with no easily identified transnational and commonly shared knowledge gap or need dominating the proposed priorities. This was partly because of wide variation of the level of detail of the proposals, ranging from widely defined topics to very specific ones. The results show that both climate change and biodiversity are already well-established domains in science and policy and therefore specific attention is needed to focus on the potential key aspects of their intersection (see Box 2). One option could be addressing climate-biodiversity nexus from the perspective of restoration and resilience of water and forest ecosystems that were relatively often mentioned.

The results showed that despite overall framing directing attention to connections between the two key environmental changes and wide recognition of interdependencies, most of the proposed research priorities focused either climate or biodiversity. This may be explained by the already strong research traditions on both issues and the composition of the respondents potentially focusing on either climate or biodiversity expertise. The results indicate challenges in building truly interdisciplinary research and innovation agendas capable of connecting or merging strongly rooted streams of environmental sciences. Interestingly, relatively high share of proposed priorities focusing on other issues than climate, biodiversity or their interactions suggests a possibility for fruitful novel openings based on thinking that do not aim to develop or converge existing research streams but create new perspectives.

Comparative insights from recent scholarly literature on biodiversity-climate nexus

The R&I priorities identified from CASRI comprehensive country reviews were generally in line with priorities highlighted by recent scholarly literature and assessment reports (IPCC, 2023; IPBES, 2024). Intertwined challenges of climate change and biodiversity loss have been addressed by several studies focusing on R&D&I needs. The literature emphasised priorities such as enhancing ecosystem resilience in changing climate, integrating conservation strategies with climate policies, fostering interdisciplinary research, and implementing effective policy interventions.

Need for integrated and synergistic approaches that reconcile climate change adaptation and biodiversity goals while supporting long-term planning and management is often highlighted by studies noting that conservation actions that halt biodiversity loss can also mitigate climate change (Shin et al., 2022). This includes better understanding of ecosystem changes resulting from anthropogenic pressures (Schlaepfer & Lawler, 2023). Williams et al. (2019) emphasizes the need to maximize the resilience of natural ecosystems to climate change through strategic prioritization of adaptation policies and environmental management maximizing stakeholder involvement. Nature-Based Solutions can address both climate change and biodiversity loss when they are carefully designed to support ecosystem health, prioritize native diversity, and involve local communities (Smith et al., 2021).

Addressing knowledge gaps through interdisciplinary, collaborative approaches is considered crucial, especially in underrepresented regions (Farooqi et al., 2022). Wang et al. (2024) note the importance of adaptive management practices, ecosystem services maintenance, and future-oriented approaches such as scenario analysis. The need for technological and methodological advancements is also often recognised. For example, use of data-intensive advanced modelling, machine learning and artificial intelligence are considered increasingly essential (Ikegwu et al., 2024).

Developing integrative, nexus-based systemic approaches is often seen as a priority. This line of research should focus on interactions between key systems such as transport, energy and food. For example, complex interactions and synergies related to climate change and biodiversity with agriculture, international trade and food consumption are key research and innovation priorities (Ortiz et al., 2021).

Effective governance approaches and policy interventions are needed to limit global warming and conserve ecosystems. Research needs involve means for advancing ambitious emissions reductions, protection and development of multi-use landscapes, and equitable access to natural resources (Pörtner et al., 2023). Both national policies and global frameworks such as the Convention on Biological Diversity (CBD) and the United Nations Framework Convention on Climate Change (UNFCCC) should be considered when developing multi-level governance.

2.3 Sustainable urbanisation

For the CASRI theme ‘Sustainable Urbanisation’ (SU) D2.1 (Maring et al. 2025) delivered a total of 118 research priorities throughout 14 countries. Eighty of these derive directly from the interactions with NKS on this theme. The other thirty-eight are obtained from thematic overlaps elsewhere (“Other” category).

Figure 9 shows the distribution of the knowledge priorities types over the of knowledge needs: S (Systemic), T (Transversal) and A (Actionable). The figures shows that most priorities relate to two or more types. This means that most of the priorities are complex and intertwined in nature. The combinations of SA and TA as well as the single category of A slightly stick out above the rest. Pure T knowledge needs were mentioned the least, instead this category was often used in combination with others.

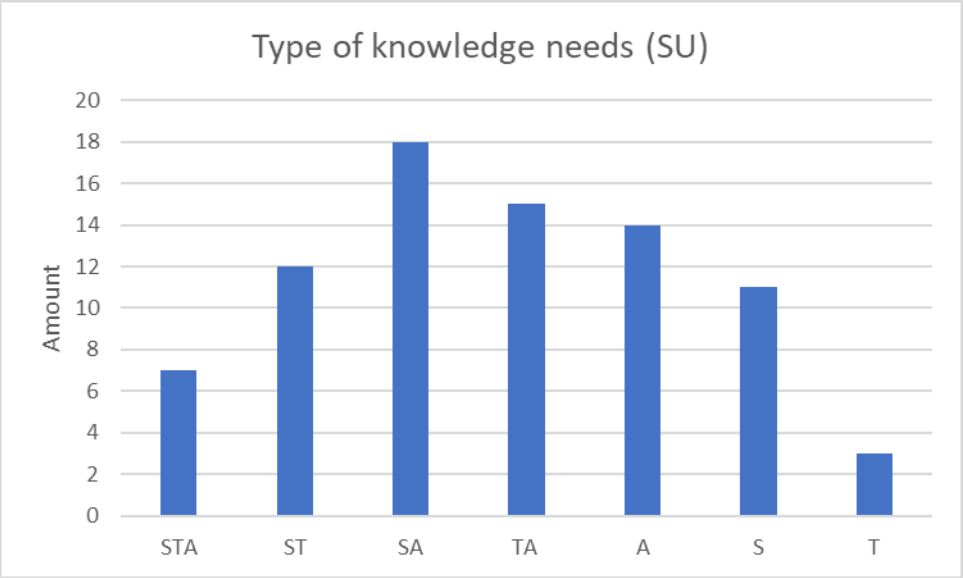


FIGURE 9. TYPES OF KNOWLEDGE NEEDS UNDER THE THEME SUSTAINABLE URBANISATION

Aggregating the main knowledge priority types reveals a focus on actionable priorities (Figure 10). This most likely reflects the nature of the Theme "Sustainable Urbanism", with many construction-type of projects and connections to object-related stakeholder demands, often requiring knowledge on how to act. The Theme has strong relations to the desire and need to improve environmental conditions for specific challenges.

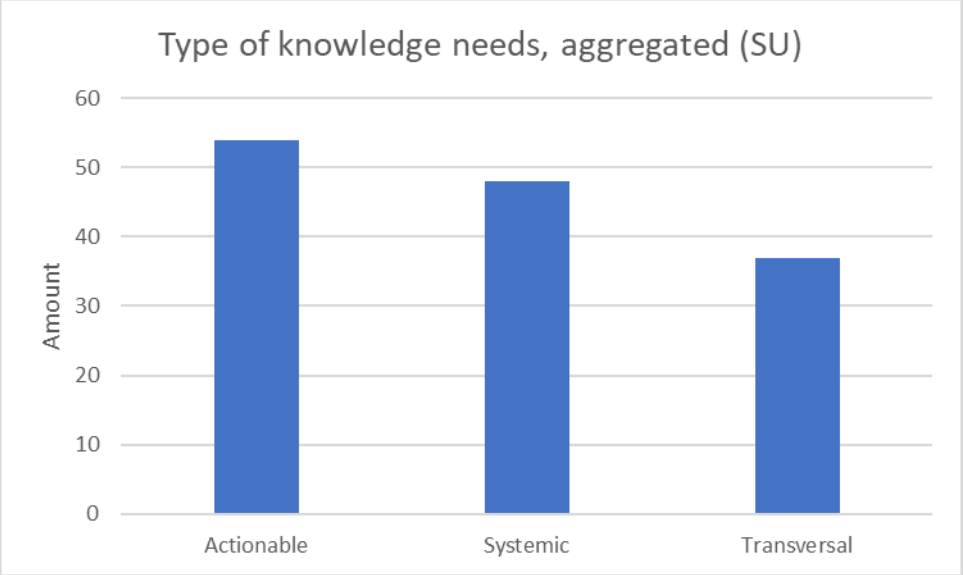


FIGURE 10. AGGREGATED KNOWLEDGE NEEDS UNDER THE THEME SUSTAINABLE URBANISATION

There are various interests to be negotiated when carrying out actions for sustainable urbanism. In that sense it is somewhat surprising that the transversal knowledge type is least represented. It seems that only a limited number of knowledge needs on this theme require specific knowledge on dealing with various stakeholders at various governance levels.

2.3.1 Knowledge needs: addressed key issues

Clustering around the political priorities shows a variety in the distribution and relevance of various key issues:

- **Security:** Security for this theme is to be understood broadly to also include the security sought through both climate mitigation and adaption. Actionable knowledge demands, which also subsume transversal and systemic knowledge needs stress the achievement of societal and urban resilience to challenges such as extreme weather event.
- **Digitalisation:** Digitalisation, while articulated, is currently not well defined. The type of processes and tools needed and their expected impact are not fully articulated. The promises stated are thus oriented around efficient transport, decision-making and increasing of transparency. Unlike other CASRI themes, the actual tools and methods (e.g. technology wise such as blockchain or AI models) to explore urban challenges are not defined or mentioned. In particular, "smart city" objectives related to digitalisation need to be further defined.
- **Regulatory efficiency & competitiveness** Key strategies and standards for climate mitigation (climate neutrality) as well as building standards and norms are mentioned throughout Europe. When it comes to a shared desire to better couple sectoral and regulatory spheres for goal attainment, almost all of the involved areas can relate. Key issues such as integrated urban development and land use, sustainability mobility make clear the need for more coordinated action across the transformative challenges. How, for what goals and for what impacts various actors and agencies engage with each other is very much the question here. This entails the need for clarity on the roles of actors and agencies, and an administrative system that supports modern and future city development (decision making processes, business models).
- **Democracy & Participation** Social vulnerabilities and co-designing of solutions with the public for wider acceptance and addressing challenges related to democratic governance.
- **Other:** A great share of other knowledge needs have been expressed that did not fit the predefined political priorities. These needs could be grouped under more traditional and non-traditional R&I objectives.
    - Traditional: in the sporadic case cross border collaboration, as it generally takes place in the INTERREG scope or among regions of similar background or climate conditions.
    - Non-traditional: urban rural nexus, as an area without clear governance roles and responsibilities in many nations.

2.3.2 SU Key issues

Table 9 summarises the identified key issues of sustainable urbanisation per cross-cutting theme and Figures 11-12 show an overview of the knowledge needs per regions.

TABLE 12. KEY ISSUES OF SUSTAINABLE URBANISATION PER CROSS-CUTTING THEME

Political priority	Key issues	Descriptive words
Security	SUS1: Green space provision	Urban resilience, nature-based solutions, ecosystem services, health and well-being, anticipating weather extremes, contaminated soils, implementation through participation.
	SUS2: Sustainable construction	Potentials for climate adaptation & mitigation, industrial transformation, sponge city, greening of grey infrastructure, standards and norms, resource flows.
	SUS3: Climate adaptation	Adaptation of urban areas to weather extremes through both technical and natural interventions
Democracy and participation	SUDP1: Participation, co-design	Defining the solutions with the general population, as to address democracy challenges and sustainability.
	SUDP2: Social vulnerabilities	Risks of climate change on communities, social vulnerabilities, stakeholder resilience, collaboration, sustainable lifestyles, mitigation of existing and anticipated impacts.
Regulatory efficiency and competitiveness	SUR1: Integrated urban planning	Transdisciplinary, multidiscipline, target groups, synergies, new partnerships, interaction of environmental mediums, perspectives new to established fields (urban planning and DNSH (Do No Significant Harm), One Health), trade-offs, task coordination.
	SUR2: Land use, sustainable mobility	Sustainable spatial urban development, interaction of mobility and land use, multi-criteria analysis, scenario development, coordinated development, behaviour analysis, multi-scale, climate neutrality.
	SUR3: Regulatory optimization	Public procurement, democracy preconditions and implications, reduction of norms with flanking of strong environmental standards, better governance, knowledge of stipulated duties and carrying out of processes, new partnerships for financing or implementation, legal permitting, zoning, administration duties, anticipatory & proactive urban development.
Digitalisation	SUD1: Data governance	Coordination, networking, skills, impact assessment of digital changes (on governance, on society), data literacy, urban services.
	SUD2: Observation, data analysis	Smart cities, smart observations and digitalization.
Other (not allocated)	SUO1: Urban-rural nexus	Balanced development, resource & energy flows, spatial typologies, synergies from interrelations.
	SUO2: Cross border cooperation	Comparison, cooperation, common challenges, upscaling

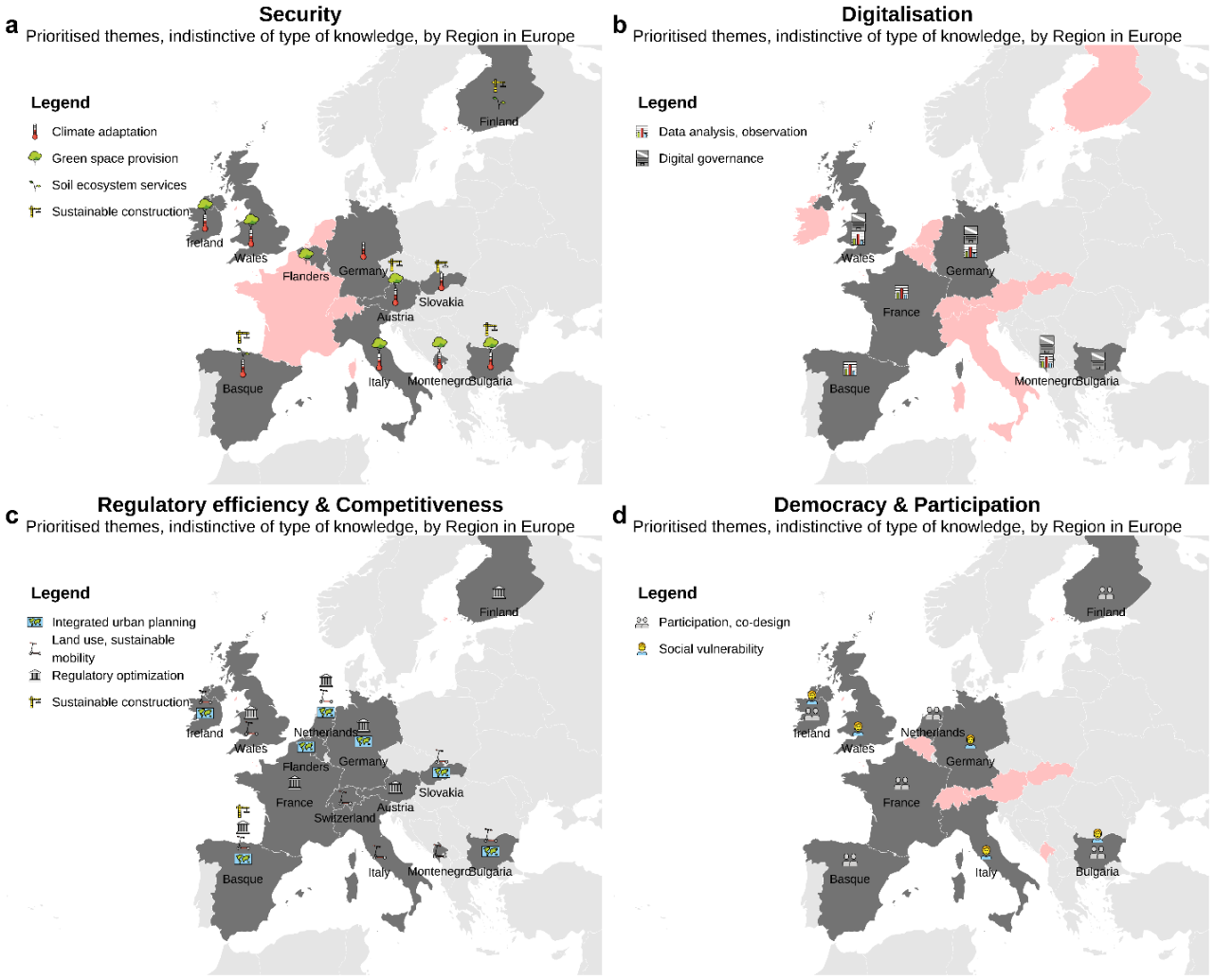


FIGURE 11. OVERVIEW OF INDICATED KNOWLEDGE NEEDS PER REGION AND SUBTHEMES.

Note: red shaded areas indicate an absence of prioritized knowledge needs in that category and region (source: Van Sluisveld).

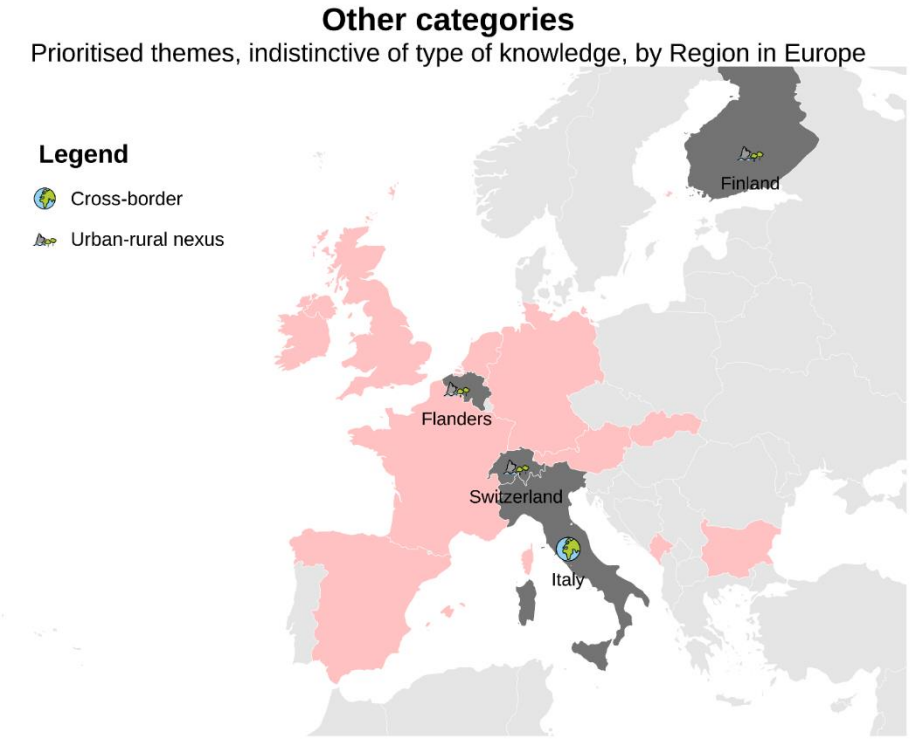


FIGURE 12. OVERVIEW OF INDICATED KNOWLEDGE NEEDS PER REGION IN THE 'OTHER' CATEGORY

Note: red shaded areas indicate an absence of prioritized knowledge needs in that category and region (source: Van Sluisveld)

2.3.3 Extracting transnational commons

For sustainable urbanism as a theme, the content of the priorities (alongside the background of NKS from which the data was gathered) can vary greatly, as they touch upon various subject matters, all which look to have their role and impact in the creation, maintenance and transformation of urban spaces. We define the transnational common as the topic in which the largest majority of CASRI regions have contributed to. By compounding all the knowledge need contributions per implied key issue, an overall impression can be drawn on which key issues contain the biggest 'need' along various cross-cutting dimensions. The ranking method for sustainable urbanisation is currently defined by the following rules:

- There was no elimination of priorities according to the expected spatial impact. This aims to account for the fact that contributions with for example only regional (R) and/or national (N) focus reflect the limited ability of EPAs or partners to state a goal of impacting other national or local jurisdictions. A tendency to shy aware from stating I/E impacts of research priorities could also reflect the situation found on the European level, where the principles of subsidiary and proportionality guide actions of the European Union on topics such as urban matters. Further, if multiple priorities on lower scales consider similar key issues, it could be assumed that the "banding together" of these in groups could mirror existing funding measures and programs on the EU level, such as the strands of INTERREG or Urbact, which look to activate cross-border partnerships to similar topics of interest. The question for prioritisation in such cases thus becomes which of the key issues on a regional or national level can be seen as to be innovative within the established framework of international urban partnerships and urban research.

- CASRI is mostly interested in cross-cutting contributions. As a result, contributions that have addressed systemic, transversal and actionable needs in conjunction with each other get priority. Ranking is decided on which contribution has greater numbers of countries contributing to it.

Figure 13 shows that a simple majority of the priorities to be centred around 4 Key issues (rank 4), accumulating about 50% of all the contributions obtained. The robustness of the ranking has not been looked into in detail for the theme sustainable urbanisation.

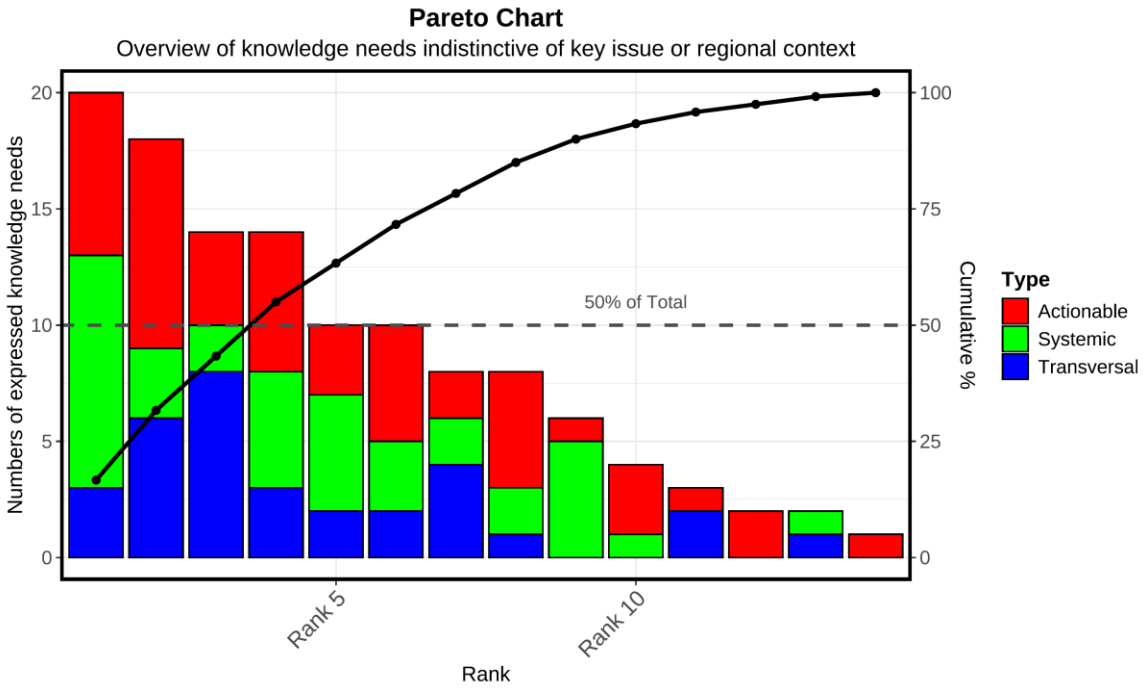


FIGURE 13. PARETO CHART OF KNOWLEDGE NEEDS PRIORITISING THE TRIAD OF KNOWLEDGE TYPES PER KEY ISSUE

2.3.4 Discussion

As with other themes in CASRI, a delineation among mode of knowledge needs (linear vs. co-produced) could be introduced to the sustainable urbanisation theme. Transposing this logic to the matters of urban affairs could be undertaken with the headings of "linear/government" to acknowledge that certain knowledge demands aim to achieve impact through traditional government approaches: supporting regulation, achieving hard set goals of climate neutrality, understanding what can be achieved through new municipal duties, etc. Such themes presume the ability of the state or government actors to understand, control and regulate urban matters. A second mode, that of "co-production/governance", could be introduced to understand research demands are set which look to change the framework and conditions through the inclusion of new partnerships and collaborations. As such collaborations can be expected to have a wide variety of qualities (i.e. co-design vs. co-production vs. co-management), further delineations would be possible. This must be considered with the backdrop of how much complexity is desired for the delineation of transnational commons related to sustainable urbanisation.

Further, the delineation used in the Resilient, net-zero, circular production system (RNZCEPS) theme to differentiate between "industrial innovation ecosystem" or "wider systemic knowledge ecosystem" has little direct relevance for the sustainable urbanisation theme. Instead, with a view towards the ecosystems (understood in the broad understanding) of actors responsible for urban matters, a delineation between "public/government" and "private/industry" could be of use. This is especially important when trying to define the reasoning for common action on key issues such as "social vulnerabilities" (e.g. for the theme of sustainable urbanisation the concept of environmental justice is useful), as the role of the state and private entities for addressing or causing vulnerabilities can differ greatly between nations.

TABLE 13. RANKED KEY ISSUES INDISTINCTIVE OF REGIONAL CONTEXT.

Political priority	Key issue	Rank
Security	Green space provision	1
Regulatory efficiency & Competitiveness	Land use, sustainable mobility	2
Democracy & Participation	Participation, co-design	3
Security	Climate adaptation	4
Regulatory efficiency & Competitiveness	Integrated urban planning	5
Regulatory efficiency & Competitiveness	Regulatory optimization	6
Democracy & Participation	Social vulnerability	7
Security	Sustainable construction	8
Other	Urban-rural nexus	9
Digitalisation	Data analysis, observation	10
Digitalisation	Digital governance	11
Other	Cross-border	12

Note: Top 8 has been deducted based on the presence of the full collection of knowledge needs in the data. The column 'describing words' provides further information on the content of the clustered knowledge demand priorities.

2.3.5 Explanation of identified SU priorities

Rank 1: Security, Green space provision

Research and innovation priority here lies on finding solutions for more resilience in urban areas, primarily through urban green and nature-based solutions. Tasks include those related to coordinate stakeholders and upscale the provision of ecosystem services (e.g. soil, rain water capture, retention and reuse, prevention of urban-heat islands) in areas in dire need of climate adaptation. Work on this transnational common would look to provide the missing arguments and links to convince decision-makers to provide the resources and backing for increasing green spaces to impact well-being in urban areas and contribute to climate adaptation against weather extremes. On the site-specific level, research could be dedicated to addressing disturbed/contaminated soils in urban areas for increasing environmental (climate) and social (health, participation) benefits. Methods mentioned include living labs, with prioritization given to nature-based vs. technical solutions.

Connected to the theme B&C

Rank 2: Regulatory efficiency & Competitiveness, Land use, sustainable mobility

Sustainable oriented spatial urban development with expected impacts on social, environmental and economic criteria. Development and understanding of scenarios for better and coordination development, from the building site level all the way to the region. Where regional focus was mentioned, a key difference to the key issue of “urban rural nexus” could be found in the focus on land use and transport issues, rather than broader flows of resources and interactions. Here a focus on the synergies offered by transport (in most some cases transport of people, in a few cases the transport of freight) with other land use concepts (land use efficiency, reduction of land take, sponge city) are included. There is explicit mentioning in the data of the desire to understand the impact of permitting processes such as zoning on issues of land take and how to balance transport with land use. Knowledge demands on the impact of transport choices upon health as well climate neutrality.

Rank 3: Democracy & Participation, Participation, co-design

Here focus on understanding social challenges e.g. social equity which are not always the main focus of established solutions (integrative thinking and action) or concepts (sponge city). Some knowledge demands look to address individual consumption patterns by engaging more directly with the consumers e.g. supporting sustainable lifestyles when related to car dependency and inefficient land use. Social innovation and (inclusive) participation processes are to be better compared and operationalized for issues related to democratic governance, e.g. by underscoring the social preconditions. Some knowledge demands look for understanding the role of engagement, co-design, co-management as a means to have desired transformational impacts. Participation in this context can also be understood as the participation of experts in discussions relatively foreign to their “main” sectoral responsibilities. Examples include the knowledge demands on how to better include “Do No Significant Harm” perspectives into urban decision making. Also, the digitalization of urban services and creation of better data governance can be mentioned. In both of these cases, close cross-overs to the respective key issues “integrated urban planning” and “digitalisation” exist.

Rank 4: Security, Climate adaptation

One possible approach for research and innovation may include the comparison and, where feasible, the coupling of the climate adaptation demands to create a more clear picture of synergies, as well as learning about transferability through comparison. Research on achieving and contributing to established strategies and understanding the implications these have on urban systems. Looking deeper into synergies from various sectors to see where further potentials may lie for environmental co-benefits (biodiversity, well-being, risk aversion).

Rank 5: Regulatory efficiency & Competitiveness, Integrated urban planning

Commonly shared environmental challenges require common approaches. Urban transformation subsumes a large amount disciplines and target groups. Holistic planning therefore includes identifying optimizations between the various departments and sectors involved. New partnerships can help leverage new potentials for goal attainment. Integrated urban planning thus includes the coupling of sectoral views and perspectives for common activities. Sometimes the combinations are innovative in their subject matter (interaction of water, soil, urban planning), other times the inclusion of new perspectives for task can add new value (incorporating DNSH, One Health (see Prata et al. 2022) principles into urban planning decisions and processes). This key issue looks into understanding sectoral synergies and trade-offs as well as the coordination which must take place between administrations and ministries to identify challenges (addressing air pollution) and pursue solutions (e.g. in the case of changing demographics and dynamic construction).

Rank 6: Regulatory efficiency & Competitiveness, Regulatory optimization

Includes a range of knowledge demands related to public procurement, democracy preconditions and implications, reduction of norms with flanking of strong environmental standards, better governance, knowledge of stipulated duties and carrying out of processes, new partnerships for financing or implementation, legal permitting, zoning, administration duties, anticipatory & proactive urban development

Rank 7: Democracy & Participation, Social vulnerability

Understanding the risks of climate change on communities and the existing vulnerabilities of various social groups. Increasing stakeholder resilience regarding climate adaptation, through more collaboration as well as behaviour changes for more sustainable lifestyle choices. Mitigation of existing and anticipated impacts through proactive development and innovative application of planning concepts (e.g. sponge city).

Rank 8: Security, Sustainable construction

Construction and climate are closely interrelated. This applied to both climate adaptation as well as climate mitigation. The priorities for this key issue mention a variety of existing climate neutrality goals in the CASRI partner areas (regional, nation and EU-level) to which construction should play a part. Achieving and understanding the impact of transformation in the construction industry requires holistic research. Further, adaptation to climate change can be supported by innovative building solutions such as sponge city and the greening of grey infrastructure. The demands such innovative uses need to be understood in order for up streaming to happen. Demands to understand include those stipulated from laws and standards defining resource flows, but also the existing political goals, e.g. regarding energy transition. In short, the context in which sustainable construction is to take place and the ways in which this must be adapted have to be better understood. This key issue looks at the potentials latent in the processes of construction (concept to realization) as well as questioning the industry standards in place for more sustainability or resilience.

Connections to themes NEFET and RNZCEPS

Rank 9: Other, Urban-rural nexus

By taking a larger spatial picture into consideration, there are knowledge demands which look to give value to the resource and energy flows which exist between urban and rural areas. Such a cross-border consideration may help to identify or understand and act upon synergies to achieve environmental improvements regarding climate mitigation, climate adaption as well as sustainable resource use.

Rank 10: Digitalisation, Data analysis, observation

Priorities related to this key issue look to improve the analysis of urban conditions through new methods. Often the specific methods aimed for are not mentioned in the priorities. But the umbrella term of smart cities, smart observations and digitalization point to a desire of having a better understanding of the urban condition and to provide a better basis with which to evaluate actions towards sustainability.

Rank 11: Digitalisation, Digital governance

Though not mentioned too often, the knowledge demands related to this key issue address aspects such as the coordination, networking, skill development, and impact assessment of the use of digital changes on governance but also the urban services provided to the public.

Rank 12: Other, Cross-border

This key issue was only mentioned twice in the data (IT and BG). The knowledge demands mentioned aim for a possible validation of research results on the topic of urban and sustainable transformation with others in similar contexts. This knowledge demand also relates to the communication and comparison of research results for defining the best proactive solutions to similar challenges.

2.4 Nature & environmentally friendly energy transition

As a result of D2.1 a total of 70 research priorities have been collected throughout 14 countries. The number of proposed priorities per country varied from 2 to 11. Five of these R&I priorities were considered to be more pertinent to one of the other CASRI themes. Consequently, they were not further considered in the analysis for "Nature & environmentally friendly energy transition", but instead included in the analysis that underpins chapter sections 2.1 to 2.3.

Table 11 provides an overview of the key issues per cross-cutting theme and Figures 14-15 show prioritised topics per regions.

TABLE 14. KEY ISSUES OF NEFET PER CROSS-CUTTING THEME

Political priority	Key issue	Descriptive words
Security	S1 Governance of NEFET	Cross-border energy collaboration, enhancing regional energy security
	S2 Technology development	Decentralisation and flexibilisation of energy supply, enhancing energy security
Democracy & participation	P1 Governance of NEFET	Stakeholders in NEFET, stakeholder engagement
	P2 Societal engagement	Positive narratives, social acceptance, political implications, behavioural change, public engagement, education
	P3 NEFET and social justice	Social impact of NEFET, reducing energy poverty risks, just transition, economic implications of sufficiency and efficiency for social groups, sufficiency concepts
Regulatory efficiency and competitiveness	R1 Governance of NEFET	Regulatory frameworks, Incentive systems in NEFET, nexus of systems, questioning technical innovations
	R2 Technology development	Decentralisation and flexibilisation of energy supply
Digitalization	D1 Digitalization and AI	Decentralisation and flexibilisation of energy supply, energy storage solutions, smart grid development
Other (not allocated)	X1 Environmental effects of energy infrastructure	Upscaling Nature-Based solutions for energy infrastructure, renewable energy projectsx
	X2 Energy efficiency in buildings and infrastructure	Improved energy efficiency, energy-saving buildings, retrofitting
	X3 Land use	Just land use, target conflicts and synergy opportunities, agro-photovoltaics
	X4 Sustainable hydrogen technology	Upscaling of technological solutions for sustainable hydrogen technology
	X5 Comparing scenarios	Foresight, identification of key levers for change
	X6 Regional/ spatial planning	Energy-based spatial planning, area development criteria

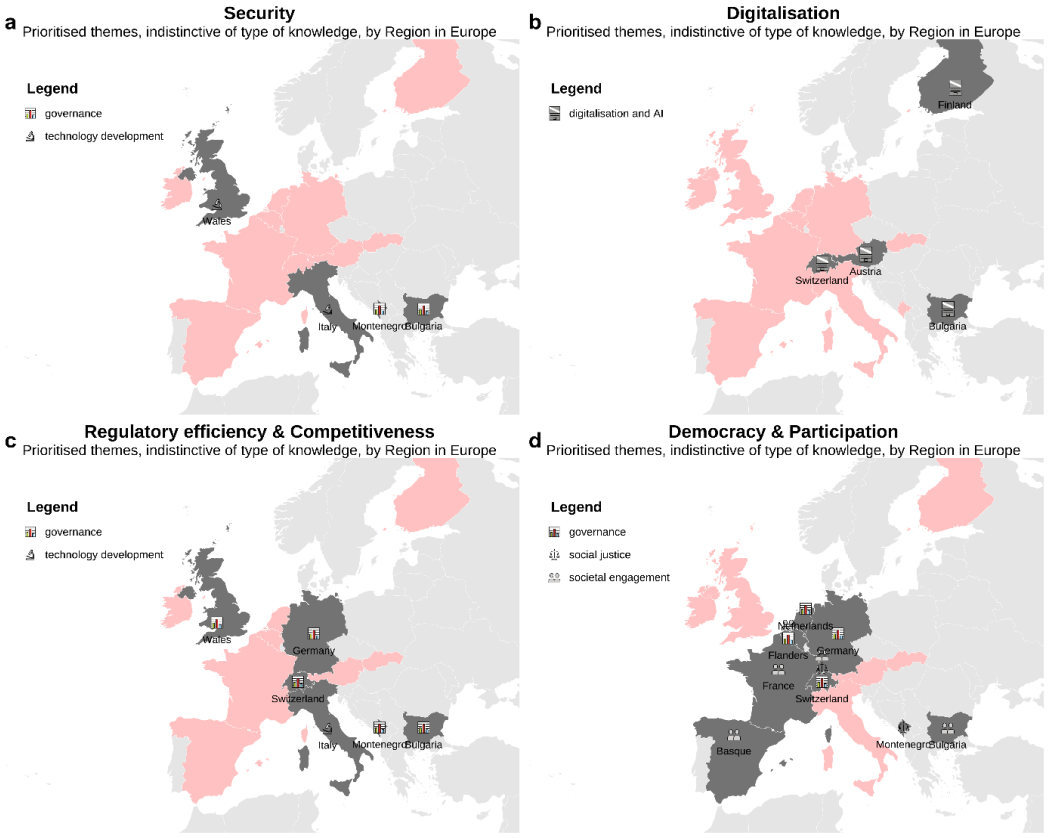


FIGURE 14. PRIORITISED TOPICS UNDER CROSS-CUTTING THEMES

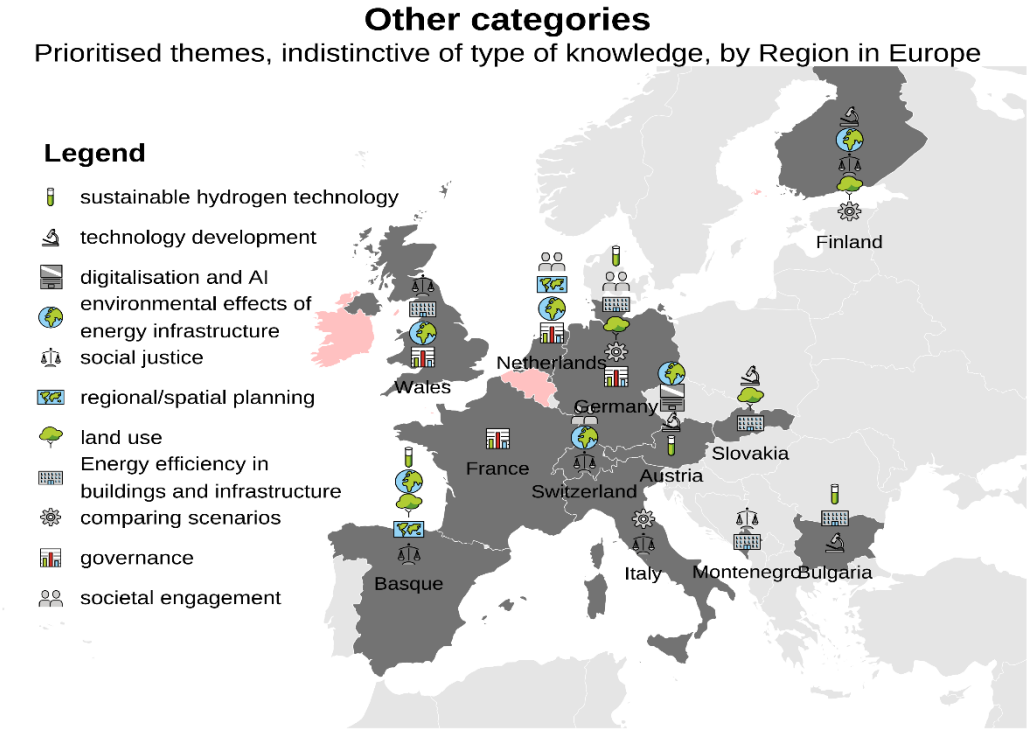


FIGURE 15. OTHER TOPICS HIGHLIGHTED

2.4.1 Key issues in NEFET

A successful nature and environmentally friendly energy transition not only depends on technological innovations or advancements, but also requires social acceptance, transdisciplinary research and scalable strategies that address the diverse challenges of the transition. This is also reflected in the transnational common priorities of the research and innovation needs of the countries. The following eleven key issues were identified — each shared by at least two and up to eight countries — and are described below.

1 Governance of NEFET*:*

Governance-related topics are identified as highly relevant, particularly regarding the topics stakeholder coordination, regulatory frameworks, incentive systems, nexus of systems and questioning technical innovations and cross-border collaboration. The key issue “Governance of NEFET” is related to the three crosscutting themes “Security”, “Participation and democracy” and “Regulatory efficiency and competitiveness. This is the most widely addressed issue, having been mentioned by eight countries: Bulgaria, Flanders (Belgium), France, Germany, Montenegro, Netherlands, Switzerland, Wales.

R&I needs/ research questions:

- How to implement roadmaps, engagement methods and having a clear understanding of different stakeholders’ roles in energy production.
- Developing policy instruments for NEFET, creating subsidy frameworks and implementation of supportive policies and enforcement of legal provisions.
- Understanding incentive systems and (long-term) impacts and effects of (de-)regulation.
- How to introduce new energy systems, drive systemic change across energy production and consumption patterns and how to stop / forbid innovations that consume too much energy or are not sustainable (e.g. air conditioning).
- How to enhance regional energy security and cooperation integrating renewable energy supply across borders.

2 Societal engagement:

Topics like positive narratives or social acceptance and political implementations as well as behavioural change and public engagement are clustered under the key issue named “societal engagement”. This key issue is strongly connected to the crosscutting theme “Participation and democracy”.

R&I needs/ research guiding questions:

- How to tell success stories, focus on win-win approaches.
- Understanding of political implications and social acceptance factors, implementation of more sustainable energy generation through public support and participation.
- Focus on behavioural change in energy consumption to move towards sufficiency, increased public awareness and participation in energy-saving practices.

3 NEFET and social justice:

These are the main topics clustered under the key issue “NEFET and social justice”: social impact of NEFET and reducing energy poverty risks and how to organise a just transition. The main transnationally shared impact is to balance NEFET with social justice concerns. There is a strong relation to the crosscutting theme “Participation and democracy” again.

R&I needs/ research questions:

- How to balance NEFET with social justice concerns and adopt socio-economic measures that will reduce the energy poverty risks.
- Understanding policy mechanisms for a just transition, understanding the factors affecting R&D trends in the energy sector.
- How to ensure equity by addressing the social and economic implications of transitioning to renewables, particularly for vulnerable communities.

4 Environmental effects of energy infrastructure:

The main topic of the key issue “environmental effects of energy infrastructure” is upscaling nature-based solutions for energy infrastructure and renewable energy projects.

R&I needs/ research questions:

- What are effective strategies for upscaling Nature-Based Solutions in renewable energy and energy infrastructure development.
- How to address social and environmental issues in infrastructure development.
- How to enhance ecosystem resilience while integrating renewable energy projects, such as solar farms with pollinator habitats or wind farms with marine conservation zones.

5 Technology development:

The main topic identified for the key issue “technology development” is decentralisation and flexibilisation of energy supply. There is a relation to the crosscutting themes ““Regulatory efficiency and competitiveness” and “Security”.

R&I needs/ research questions:

- How to enhance security and resilience of renewable energy systems.
- How can local production of technologies contribute to the competitiveness and resilience of renewable energy systems.

6 Energy efficiency in buildings and infrastructure

The main topic of this key issue is “improved energy efficiency in buildings and infrastructure”.

R&I needs/ research questions:

- How to reduce energy consumption and meet energy demand more efficiently.
- How can innovations in energy efficiency, retrofitting, and smart technologies support a nature- and environmentally friendly energy transition while contributing to net-zero goals.
- In what ways can these innovations enhance ecological sustainability and environmental health in buildings and infrastructure systems.

7 Digitalisation and AI in NEFET:

The main topic is decentralisation and flexibilization, especially in terms of AI and energy storage solutions and smart grid development. There is an obvious direct connection to the crosscutting theme “Digitalisation”.

R&I needs/ research questions:

- How to integrate AI into the energy transition to enable environmentally friendly and decentralised energy systems, supported by appropriate legal and economic frameworks.
- What regulatory and economic instruments are needed to facilitate digitalised, flexible, and nature-compatible energy systems, while ensuring data protection.
- How can innovations in energy storage and smart grid management contribute to a sustainable and environmentally sound energy transition, particularly under decentralised supply structures.

8 Land use:

The main topics identified for the key issue “land use” are just land use and target conflicts and synergy opportunities.

R&I needs/ research questions:

- How to address land use conflicts between nature conservation and renewable energy deployment at regional level to enable an environmentally compatible energy transition?
- What governance approaches are effective in reconciling nature protection goals with net-zero targets in the context of expanding renewable energy infrastructure.
- What is the ecological and socio-economic potential of agro-photovoltaics as a land-use strategy for NEFET.

9 Sustainable hydrogen technology:

Upscaling of technological solutions for sustainable hydrogen technology is the main topic of this key issue.

R&I needs/ research questions:

- Which conditions are needed to ensure that scaling up sustainable hydrogen production contributes to emission reduction without compromising environmental integrity.
- How can the upscaling of green hydrogen technologies be aligned with environmental sustainability and nature protection goals across industrial and transport applications.
- What are the ecological impacts and potentials of using industrial waste for sustainable hydrogen production, and how can these be optimised through pilot projects.

10 Comparing scenarios:

Comparing scenarios is mainly about foresight and about the identification of key levers for change.

R&I needs/ research questions:

- How can foresight and scenario comparison support environmentally sustainable energy pathways beyond 2030, considering ecological risks and trade-offs.
- What methodologies are most effective in evaluating the environmental and societal costs and benefits of implementing vs. not implementing different energy transition scenarios

- How can robust scenario planning inform strategic decisions today to ensure long-term ecological resilience in future energy systems.

11 Regional and spatial planning:

This key issue is mainly about energy-based spatial planning and area development criteria.

R&I needs/ research questions:

- How can spatial planning frameworks integrate nature development objectives into renewable energy expansion strategies to minimise ecological disruption and maximise environmental co-benefits.
- What area development criteria (e.g., large-scale water management) support effective deployment of nature- and environmentally friendly renewable energy infrastructure.

2.4.2 Summary

These proposals range from broad thematic areas to highly specific research questions, reflecting a *systemic, transversal,* and *actionable* approach. The findings indicate that while energy transition is well-established within scientific and political discourse, particularly in technological terms, greater attention must be given to its environmental impacts. These transnational common priorities highlight a collective commitment to balancing nature and environmentally friendly as well as social dimensions of the energy transition, with the goal of creating a sustainable and social just future. Effective coordination between stakeholders, particularly at regional level, is crucial to tackling these challenges. The CASRI triangle reflects the systemic approach to the nature- and environmentally friendly energy transition. The energy transition field prioritizes integrating expert advices to address target conflicts and ensure regulatory compliance. At the transversal level, coordination among stakeholders, involving various responsibilities and spanning different spatial levels of governance, along with the insights gained, can inform and shape research agendas. Action requires common knowledge on how to deal with a nature and environmentally friendly energy transition in terms of upscaling.

Central to this process are effective governance frameworks, which ensure stakeholder coordination, regulatory efficiency, and cross-border cooperation. Additionally, societal engagement plays a crucial role in promoting public support, encouraging behavioural change, and ensuring that the transition is just and equitable, especially for vulnerable communities. Addressing the environmental impacts of energy infrastructure and integrating nature-based solutions is essential. The role of digitalisation, AI, and decentralised energy systems also emerges as a critical aspect of enabling a more flexible and resilient energy infrastructure. Furthermore, ensuring that the energy transition aligns with broader goals, such as reducing energy poverty and fostering social justice, is crucial. Overall, the nature- and environmentally friendly energy transition requires a comprehensive approach that balances technological, social, environmental, and economic considerations to achieve long-term sustainability.

2.5 Key issues outside the four CASRI themes

Altogether, 90 different R&I priorities were proposed under the theme “other”. The number of proposed priorities per country ranged from one to 16. These figures are indicative, since some proposals presented a single issue, while others combined several issues related to each other. All the characterisations were brief, but their style varied, both in terms of specificity and focus. Different priorities were proposed, from clearly defined and tightly focused to certain technology or specific policy target, to more general and wide-spanning proposals scoping potentially relevant issues.

Within the “other” theme, systemic knowledge stood out as the most mentioned knowledge need (Figure 16). It was mentioned together with actionable or transversal knowledge by 40.0% of all proposals and as the sole knowledge need by 33.2% of the proposals. Generally, proposals advocated for a systemic change that addresses interconnected problems rather than simply treating symptoms in isolation. They called for a shift towards more holistic, equitable, and sustainable ways of thinking and acting. Only 5.6% of the proposals were labelled primarily as actionable knowledge. For less than a tenth (8.9%), transversal knowledge was considered as the sole knowledge need. A half (50.0%) of the proposed R&I priorities were considered capable of addressing different types of knowledge needs simultaneously.

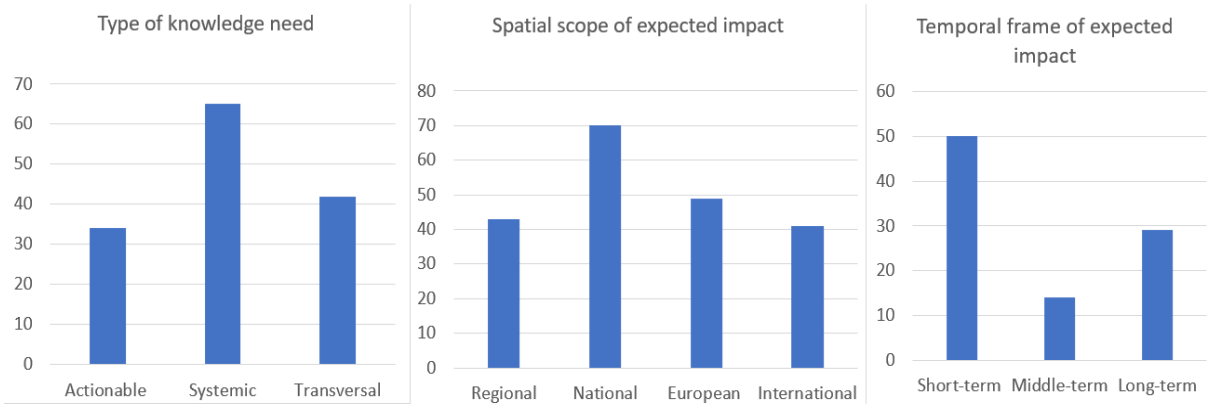


FIGURE 16. OVERVIEW OF PRIORITIES SUGGESTED OUTSIDE THE FOUR CASRI THEMES

Note: Types of knowledge needs, spatial scopes and temporal frames of other suggested priorities

Characterisations of the expected impacts of proposed R&I priorities mainly pointed to short-term impacts. About one out of ten (11.1%) priorities focused solely on long-term impacts while over a third (34.4%) focused solely on short-term impacts. A quarter (25.6%) of the proposals were characterised with impacts spanning over different timescales. Temporal scope of impacts was not presented for over a fourth (22.2%) of the proposals, indicating difficulties on identifying the impacts among the respondents.

Most (77.8%) of the proposed R&I priorities were considered to have impacts over different spatial scales. Notably, 17.8% of priorities were considered relevant for all spatial scales, from national to international level. Over a tenth (11.1%) of the proposed priorities were considered relevant primarily on national level, while two thirds (66.7%) were considered relevant both for a national and wider geographical scale.

Table 12 presents the issues identified and their relation to cross-cutting themes. Generally, the need for transformative change at multiple dimensions of development was recognised, including

different spatial scales, individual level changes as changes in societal structures. The suggested research priorities highlight the importance of recognizing the interconnectedness of environmental, social, and economic issues and addressing cross-national issues when considering national priorities.

TABLE 15. KEY ISSUES HIGHLIGHTED OUTSIDE THE FOUR CASRI THEMES

Political priority	Key issue	Description/keywords
Security Digitalisation	S1 Assessing trade-offs, synergies and risks and managing conflicts	O1 Comprehensive assessment of risks, impacts of crises and geopolitical tensions on sustainability pathways (e.g. resources). O2 Awareness building with multi-system modelling, assessment of conflicting goals, synergies, systems thinking. O3 Avoidance of non-intended effects of innovations, novel risks, cumulative effects (e.g. geoengineering) O4 Long-term monitoring. comparative sustainability research, interdisciplinary and cross-sectoral policy comparisons
Regulatory efficiency and competitive-ness	R1 Scaling of experimentations and innovation diffusion	O5 Coordination of initiatives and experimentations, innovation diffusion, rapid scalability, cross-sectoral innovation policy
Participation and democracy and Digitalisation	P1. Policy-relevant understanding of transformative change	O6 interdisciplinary understanding the processes of organisational social and behavioural change, humanities, education, incentives and obstacles of change, misinformation, democracy O7 Utilisation of data, AI, policy demands for data. Public participation and structures supporting just transition, participatory citizen science, vision building, effective awareness raising O8 Policy coherence and effectiveness, Regulative practices, environmental law and legal structures including non-humans
Regulatory efficiency and competitive-ness	R2 Reconfiguration of economic system, sufficiency and justness	O9 Sustainable consumption, sufficiency, (dis)incentives for overconsumption O10 Sustainable finance, regenerative economic development, economic paradigms O11 Inequalities, social science approach on just transition O12 Mission-oriented industrial policies for sustainability; Corporate governance
Other		O13 Environmental and ecosystem/one health, monitoring of novel stressors, biomonitoring O14Land use and resource management, soil sealing O15 Demographic change O16 Cultural heritage, cultural ecosystem services O17 Sustainable mobility, physical activity O18 Food system, agriculture, novel foods, blue economy 019 Development and applications of novel environmental technologies, e.g. genetics O20 Cross-border collaboration, global logistics

Several overarching topics could be identified. Interdisciplinary research and collaboration were seen as essential to tackle the complex challenges of sustainability. In practice, interdisciplinary was considered as integrated perspectives from various disciplines like economics, social sciences, health, and the arts and humanities. There was also an emphasis on transdisciplinary and participatory approaches and inclusive decision-making processes. Many countries emphasized research needs related to societal transformation and the need to move beyond technocratic solutions and embrace a more holistic understanding of sustainable development. This includes participatory processes, addressing social inequalities ("just transition"), and incorporating diverse voices in decision-making. Focus on behavioural change, effective communication strategies and public awareness were also highlighted.

A variety of different individual topics were suggested, from general level issues such as societal transformation processes and just transition, democracy and participation to sector-based considerations such as agrarian transitions for sustainable food systems. Issues ranged from conceptual and legal framing of the human-nature-relationship to concrete issues of sustainable mobility.

Environmental justice in a context of eco-colonialism can be considered as potential emerging topic. This involves a call to deconstruct colonial power structures and address systemic inequities in environmental decision-making and impacts. Another potential emerging topic was the relationship between culture and ecological sustainability. This involves recognizing the value of cultural practices, traditional knowledge, and arts in fostering ecological sustainability and human long-term well-being. Development of novel approaches and technologies that integrate scientific knowledge with social, economic, and cultural insights was highlighted. Overall, these topics underline the importance of local and indigenous knowledge.

Research needs and innovation priorities clearly have variation across nations, but some underlying shared topics can be identified. Specific research priorities mentioned included issues such as food systems transformation, environmental policy and governance and geopolitical dynamics. Understanding the complex links between climate change and various sectors (health, agriculture, ecosystems was a recurring theme. Sustainable food systems, including regenerative agriculture, reducing reliance on high-input practices, and addressing global food security challenges was addressed. Recognizing the influence of geopolitical conflicts on resource flows and sustainability efforts was seen as an issue requiring research on governance structures and international cooperation. Countries also highlighted evaluating the effectiveness of existing policies, exploring alternative policy instruments, and promoting multi-level governance approaches for addressing environmental challenges.

Proposals on environmental science generally addressed understanding ecosystems, mitigating pollution, and conserving resources. Examples included advanced methods for assessing sustainability, including true cost accounting, evaluating the effects of measures in one area to other areas and assessing impacts on equity. Proposals on governance and policy examined the multi-level governance and policy measures, role of laws, institutions, international cooperation, and public participation in driving sustainable change. Proposals on social impacts and equity addressed how sustainability impacts different communities, promote justice, and foster inclusive decision-making. Examples included tackling challenges posed by consumerism, promoting equitable lifestyles, engaging businesses effectively in addressing "wicked" problems and ensuring equitable

environmental policies. Interlocking of sustainability and security agendas and balancing sustainability conflicts were noted.

Transversal knowledge was typically noted together with systemic or actionable knowledge and only occasionally highlighted as a stand-alone knowledge need. The proposed priorities addressed several interconnected *systemic issues* that hinder progress toward sustainability, including:

- Traditional siloed structures and practices separating environmental, social, economic, and political spheres. This causes that their interdependence. is not recognized sufficiently by researchers and policy makers. This leads to short-sighted solutions that address symptoms rather than root causes.
- Power dynamics, including dominant actors outweighing the marginalized communities and grassroots movements. This can result in policies that prioritize profit over people and planet.
- Consumerism and resource depletion with current economic model based on consumption. This is driving unsustainable levels of resource extraction, waste generation and pollution.
- Lack of transparency and accountability, resulting from complex supply chains and opaque decision-making processes making it difficult to track environmental and social impacts.
- Limited public awareness and engagement because of limited understanding of complex sustainability issues, leading to inaction or solutions based on misleading premises.

The proposed priorities highlighted some aspects of *actionable knowledge*: defining clear research priorities, efficient means for connecting research to policy and practice, empowering diverse stakeholders and fostering innovations for transformative change. These include:

- Monitoring, evaluation, and learning that allows for adaptive management strategies based on new knowledge and evolving contexts.
- Inter- and transdisciplinary research encouraging collaboration and holistic solutions by bridging the gap between scientific disciplines and practical applications.
- Economic, legal and socio-behavioural research creating effective ways of raising public awareness of environmental issues, to implement public policy, remove regulatory barriers and adapt alternative economic paradigms for sustainability
- Increased public awareness and engagement empowering stakeholders to participate in sustainability efforts. Research focusing on communication strategies and behavioural change can identify structural impediments and empower individuals to contribute to solutions.

3 Suggestions for revised themes and prioritised key issues

The analysis using the materials from the national reviews have been discussed in a transnational expert workshop organised in Helsinki, 26-27 May 2025. The workshop included 57 participants from 47 European organisations and representatives from 13 CASRI case countries / regions. The respondents represented wide-based expertise on environmental and sustainability research, funding, management and policy.

The overall focus of the workshop was on future-oriented approaches to sustainability challenges, addressing systemic, actionable and transversal knowledge relevant for Europe, Environmental Protection Agencies and partners alike. Two group work sessions were arranged in order to reflect on the findings from the analysis, collect insights and guidance on elements that transcend national contexts to which a transnational research agenda could benefit.

3.1 Resilient, net-zero, circular production systems

The group work focusing on the results over the theme ‘resilient, net-zero, circular production' systems’ invited 11 experts across 9 different regions in Europe (GB, NL, DE, AT, CH, IT, ES, FI, SK) to reflect on the initial proposition for key issues related to the theme ‘resilient, net-zero, circular production systems’ based on data collected throughout the separate country reports. Overall, the stakeholders represented a diverse spectrum of affiliations. With over a third of the participants represented knowledge providers and less than a third knowledge end users (Figure 17).

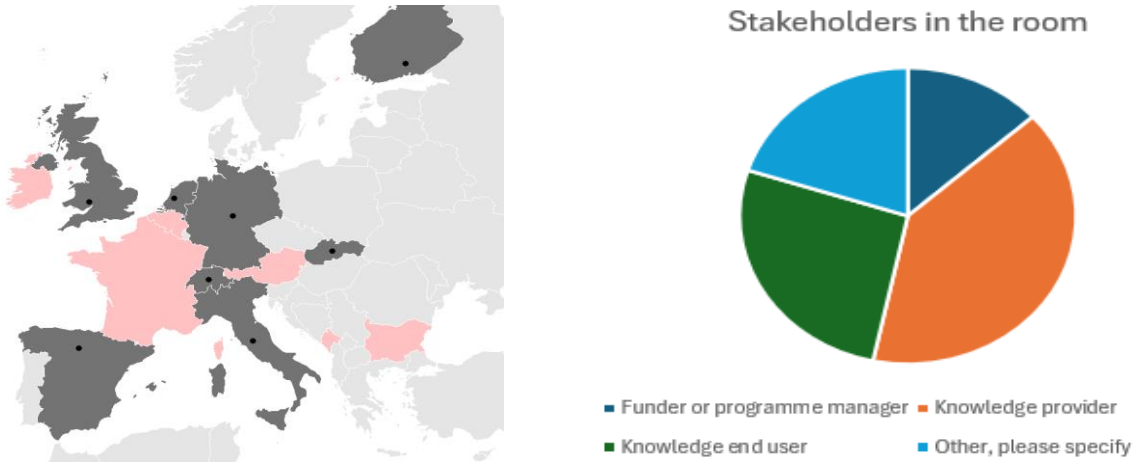


FIGURE 17. BREAK-DOWN OF PRARTICIPANTS AFFILIATIONS

During the workshop the participants were invited to distribute 3 votes along the provided ranking tables based on the results presented in Chapter 2.1. The participants could vote in support of the (i) identified key issue (the ‘main level’, indifferent of the focus areas) or (ii) even very specifically on a specific focus underlying the key issue. Each vote has been treated on equal basis to the initial codification along the country reports. This means that an additional 11 x 3 = 33 points could be redistributed strategically across the existing categories to boost the underlying score.

Overall, the participants clustered around the same four (4) existing key issues, with only limited scatter of single votes around specific issues elsewhere. This implies a rather strong unified signal towards specific key issues, with a deliberate change to the ordering of the ranking (see also Figure 18 below).

Strong (cluster) signals

- The participants generally agreed with the compiled country level results for 'security of resource supply' on an 'industrial ecosystem' level (F1-F3, originally ranked 1st), validating this key issue although indicating a different order of the underlying foci. Particularly renewable, clean and secondary feedstocks and enabling conditions for green business models have been commented on as important under this heading. Less feedback was received for the same key issue on a systemic perspective (F4-F5), although it received overall approval (colour coding indicating 'supportive') and a single vote (F4).
- General competencies and capabilities to address systemic risks on an integrative level have been upvoted (originally ranked 5th). Particularly ex-ante or foresight capabilities have contracted specific votes (F13). No full consensus exists on the key issue as negative colour coding has been used to express removal.
- Subsequently, key issues related to the theme 'Democracy & Participation' have been upvoted significantly (F10-F11 and F19-F21). Elements facilitating just and fair transitions have been acknowledged to be difficult to make actionable, but at the heart of successful transformative change towards sustainability. Some suggestions were provided to not address this in too aggregated terms (distinguishing on the level of social or economic systems as described in F10-F11) but operationalizing on more applicable level (e.g. with focus on strategic behaviour of specific actors, e.g. F19-F20) (therefore proposing to remove F10-F11 from the deck and approach it as F19-F20).
- Key issues around 'Regulatory efficiency and competitiveness' have also been significantly upvoted to make an appearance on the original deck (particularly F28-F29 under 'regulatory system'). The subtheme in general has received the greatest amount of comments, mostly indifferent comments indicating a need to further articulate more precise research questions (e.g. political economy oriented, best public instruments). More normative responses are expressions of support for EPAs to also lead the way (not just on accountability, but also setting of standards) and frustrations around the 'do no significant harm' principle not being adopted well into existing policy frameworks.
- The theme of 'Digitalisation' has been downvoted on all accounts, receiving negative or indifferent colour coding. Overall digitalisation and the key issues identified under this heading have been commented on as a private interest (e.g. efficiency improvement) and not for a public agenda-setting context. The CASRI process (taking several years to deliberate and operationalize a research agenda) was also perceived as inappropriate to tackle the theme of 'Digitalisation' given its fast paced and disruptive developments.

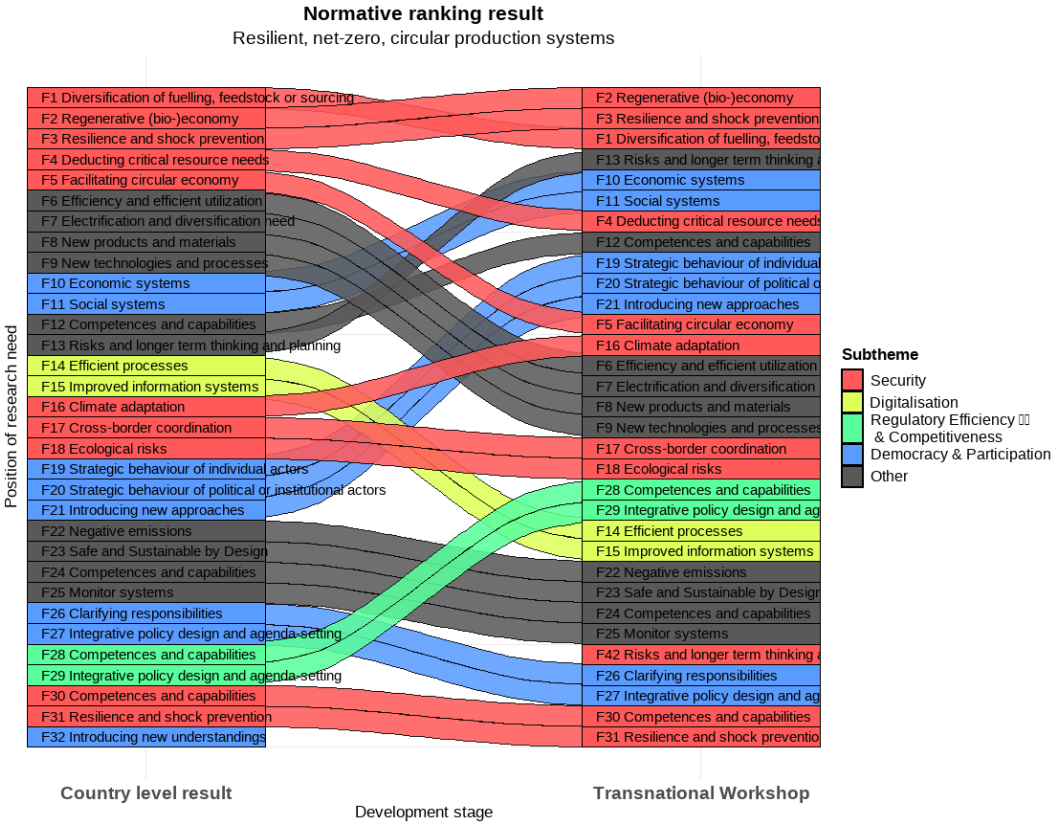


FIGURE 18. OVERVIEW OF THE SHIFT IN RANKING ORDER DUE TO EXPERT DELIBERATIONS.
Note: view limited to the top 32 focus areas or 13 ranks for readability considerations.

Weaker (Individual) signals

- The key issue of “Climate Risk” has received a smaller number of specific votes, for which the majority particularly centred around F16 (Climate adaptation), creating a breach in foci for this key issue across the deck. Feedback provided by the participants has however been in support across the other foci (commenting with colour coding). For F17 (cross-border coordination) the need to explore obstructing policies around EU, specifically in the agricultural and environmental domain, has been addressed. For F18 (Ecological risk) it was mentioned to supplement with social and economic risk.
- A systemic view on more general ‘Innovation’ key issues received support for F22 (Negative emissions) in votes and comments. Mixed signals have been provided for F23 (Safe and Sustainable by Design), suggesting a focus on ‘forever chemicals’.

3.2 Biodiversity and climate

The group work, focusing on the key issues under the theme “Biodiversity and Climate”, involved 20 expert stakeholders from various countries. Most participants had strong expertise in environmental studies, including biodiversity and climate science. Most participants represented either knowledge providers (such as universities and research institutions) or government bodies (e.g. ministries). The discussions were organised around modified versions of Tables 6–9 (see Chapter 2.2) and Table 14 (see Chapter 2.5), which summarise the key issues related to the biodiversity and climate theme and provide an opportunity to discuss key issues that complement the four CASRI themes. Following the group discussions, participants had an opportunity to vote the most important key issues with three

votes and shortly reflect on voting results. Because of the heterogeneity of the theme, prioritisation focused on clarifying the ranking of key issues under subthemes of climate-biodiversity interactions, biodiversity, climate and other issues.

Based on the group work discussions, it is suggested that the original title of the theme (Biodiversity & Climate) could be modified to better highlight the need to specifically focus on systemic interactions between different environmental challenges instead of research streams focusing on both issues separately. Such an integrative framing is fundamental for addressing potential trade-offs and synergies between various issues, and for pursuing sustainability goals in a holistic manner. Emphasising interactions—rather than treating biodiversity and climate as two separate issues—enables, for instance, the consideration of the triple planetary crisis that was highlighted by the participants. The concept of triple planetary crisis includes pollution alongside biodiversity loss and climate change. However, it should be noted that the proposed integrative focus is not intended to undermine the importance of research that concentrates on specific aspects of biodiversity or climate change. Based on these considerations, a modified title for the theme could be: “Interactions of Environmental Challenges: Biodiversity and Climate Nexus”.

Two closely related key issues, specifically focusing on the intersection of biodiversity and climate, were highlighted by the group as the most important. First, there was a call for improved generation and utilisation of data to identify and manage interconnected biodiversity and climate risks—and opportunities. Second, cross-sectoral integration across different scales of activity was emphasised as a policy-relevant R&I need, extending also beyond biodiversity and climate-related activities. A key consideration underlying both issues was the importance of an integrative approach.

When focusing on climate issues, the group identified knowledge needs related to effective climate policy, regulatory frameworks, and policy implementation as a clear priority. In relation to biodiversity, the priority was placed on knowledge needs concerning comprehensive, up-to-date, and policy-relevant ecosystem monitoring, as well as understanding biodiversity change. More generally, the importance of environmental monitoring was also emphasised, noting that knowledge generation must be followed by (policy) action. The need for innovative funding and support mechanisms was discussed related to all sustainability research and innovation.

In relation to the other research priorities identified in the national reviews (in addition to four our original CASRI themes), the group highlighted two main key issues. First, the need for a better understanding of transformative change was emphasised. This requires both deeper insight into the processes of organisational, social, and behavioural change, and improved utilisation of data—drawing on tools such as artificial intelligence, participatory citizen science, vision building, and awareness-raising initiatives. Second, knowledge needs related to the reconfiguration of the economy were highlighted. This includes considerations of human challenges such as sufficiency and justice, sustainable consumption, sustainable finance, incentives and disincentives for action, and regenerative economic paradigms.

3.3 Sustainable urbanisation

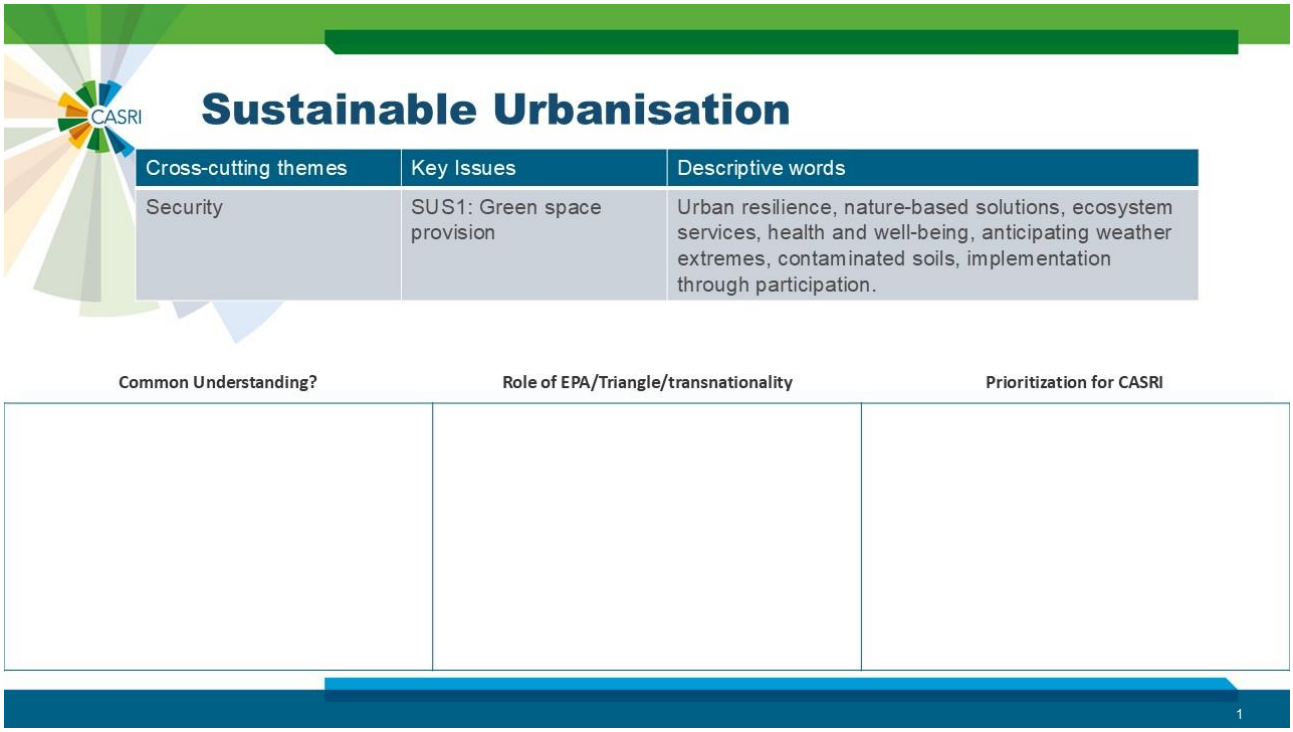
For the theme of Sustainable Urbanisation, 10 experts from 6 European nations and regions (Basque, Flanders, FR, IT, NL and SK) reflected on the initially proposed key issues (Chapter 2.3). Overall, the stakeholders represented a diverse spectrum of affiliations, with four representing the group of “funder or programme manager”, four others representing “knowledge provider” and two

from the group “knowledge end users”. From an organisational perspective, six were from “government” institutions and 4 with “research” affiliations regarding their current roles.

During the workshop on the 26th of May, 2025, the data collection and evaluation of the various country report summaries was presented to the group. One round of enumeration for each key issue took place. The participants were then asked to add comments to each key issue as they saw fit to pose questions, state opinions (both positive and negative) as well as general commenting. The feedback of the participants was gathered on printouts and grouped into the two categories of “common understanding” (to gather and address any possible uncertainties) as well as “triangle/EPA/transnational commons” (to highlight points related to the specific goals of the CASRI project, namely to address the STA triangle (Box 1), role of EPAs etc. in sustainable transformation and the grouping of commonalities among the nations towards transnational commons). The comments gathered was then reflected upon in a group setting, with each note being read out loud and where needed more context asked for and provided by the author of the note. The purpose of this exercise was to solidify the understanding of the priorities for all in the room and to create a common basis for the voting.

Having established a common understanding, each participant was invited to distribute 3 votes among the provided tables. The participants were asked to vote in support of their favourite identified key issue with view to the CASRI goals. Votes were gathered in the third box provided on the printouts (“prioritization for CASRI”) (Table 13).

TABLE 16. EXAMPLE OF PRINTOUTS USED DURING THE “SUSTAINABLE URBANISATION” GROUP WORK



Note: here for priority sus1: green space provision

In total 24 votes were distributed (which means not all available votes were used). The most voted for key issues among the workshop participants were:

- SUR2: Land use, sustainable mobility (6)
- SUR1: Integrated urban planning (5)

- SUDP2: social vulnerabilities (5)
- SUS3: Climate adaptation (4)
- SUS2: Sustainable Construction (2)
- SUDP1: Participation and co-design (1)
- SUD1: Data governance (1)

Not given any votes were the following priorities:

- SUS1: Green space provision
- SUR3: Regulatory optimization
- SUD2: Observation, data analysis
- SUO1: Urban-rural nexus
- SUO2: Cross border cooperation

Overall, it can be seen that participants clustered across the same four (4) existing key issues, with only limited scatter of single votes around specific issues elsewhere. The key issues of those pertaining to “Security” (“climate adaptation”, “sustainable construction” and “green space provision”) as well as the key issues of “social vulnerabilities” and “Land use, sustainable mobility” plus “Integrated urban planning” were ranked highest in the workshop.

By giving each vote during the workshop an equal value as the initial codification of the theme key issues as per the country reports, then a new ranking can be assumed. This implies a rather strong unified signal towards specific key issues, with minor changes to the original ordering of the ranking (see also Figure 19).

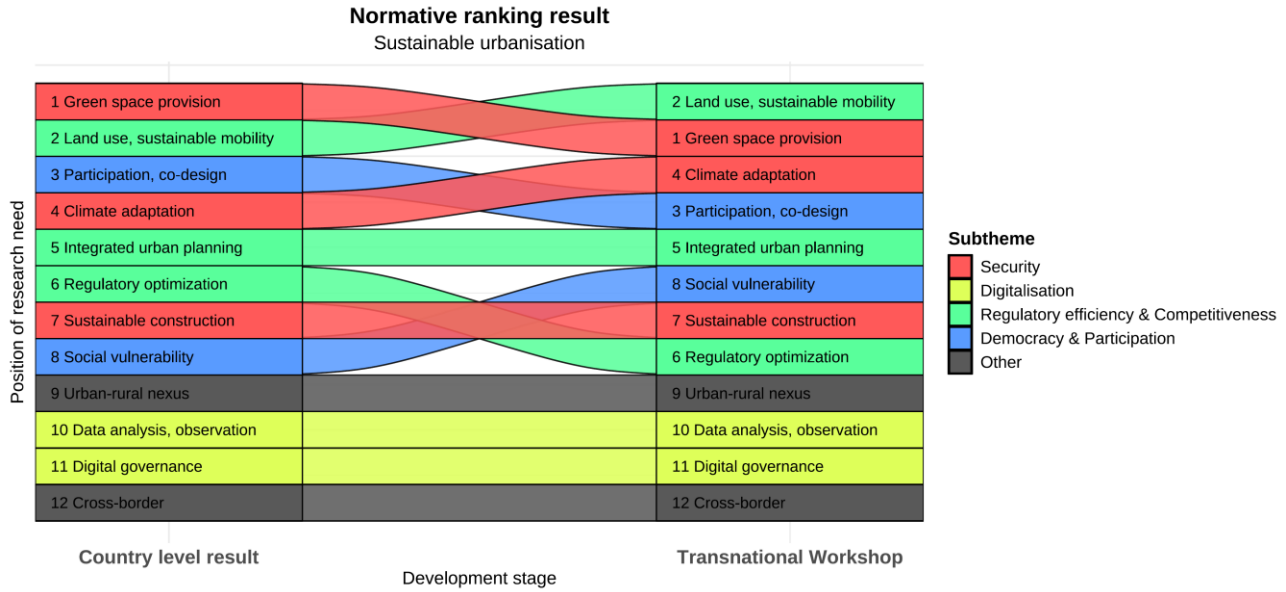


FIGURE 19. NORMATIVE RANKING RESULTS
Note: Source: van Sluisveld & Eckert (2025)

Discussion

The valuable discussion of the workshop showed important distinctions to the key issues which make a reorganization necessary.

- Consolidation of key issues under the cross-cutting theme “Security”: In the discussion with the experts, it was determined that the proposed key issues under the cross-cutting issue of Security were of such a related nature, that they would work better consolidated. This has a consequence of combining the key issues of “sustainable construction”, “climate adaptation” and “green space provision” to be subsumed into one key issue. The new key issue looks to include all of the aforementioned topics under the title of “building and greening initiatives to address climate”. This showcases how on the one hand actions related to either greening or sustainable construction can aim for similar climate-related goals. Further, understanding the combination of measures i.e. greening of buildings is also a viable research priority.
- Highlighting support for key issue “social vulnerabilities”: One key issue which was ranked somewhat ambivalently during the literature review (8th) was able to gain two places (to 6th) in the ranking through the relatively high number of votes given during the workshop. This stresses the participants ideas that the key issue provides not only a possible innovative topic for research but also has important connections to the goals of the CASRI SRIA, namely to identify research priorities which also relate to the competencies of EPAs. Being public institutions with clear mandates for the services to the public of their jurisdiction, it is easy to see how issues of social relevance may relate to the underlying principles of the EPAs (protection of environment for all, supporting of the common good, etc.).
- Integrated planning in search of more definition (EPA roles): Two fields related to the cross-cutting theme of “Regulation” were highly voted upon during the Helsinki workshop, namely “integrated urban planning” and “land use, sustainable mobility”. Whereas the latter touches upon identified sectoral views to be integrated with each other, and also builds upon a long established history of activities combing these, the former priority is rather open ended. Whereas this means “integrated urban planning” can be assumed to subsume the key issue of “land use, sustainable” mobility, the discussion at the workshop stressed that the key issue “integrated urban planning” can be seen as a method with which to relate existing EPA competencies with each other, ideally in new and novel ways. It should be a future task of the theme lead and CASRI partners to identify which these exactly are to define (an) innovative key issue(s) for the next steps of the project.

3.4 Nature, environmentally and socially friendly energy transition

The group work phase focusing on the key issues under the theme "Nature and environmentally friendly energy transition" involved 10 experts across 9 various regions in Europe. The participants reflected on the initially proposed key issues (Chapter 2.4) related to the strategic research agenda based on data collected throughout the separate country reports.

Overall, the stakeholders represented a diverse spectrum of affiliations, with 4 representing the group of “funders or programme managers”, 3 others representing “knowledge providers” and 4 from the group “knowledge end users”. From an organisational perspective, 3 were from “government” institutions and 6 with “research affiliations” regarding their current roles. The majority of participants had expertise in cross-cutting environmental topics.

During the workshop on the 26th of May, 2025, first of all the data collection and evaluation of the various country report summaries was presented to the group. The participants were then asked to reflect on and comment upon the key issues related to the theme. There was also the opportunity to discuss additional key issues that could complement the four CASRI themes. Following these discussions, participants prioritised the most important key issues with three votes per person and briefly reflected on the outcomes.

During this co-design process of the workshop, it became evident that the original title “Nature- and environmentally friendly energy transition” does not fully capture the complexity of the challenges ahead. Participants agreed that the energy transition must also explicitly address social dimensions, which are essential for ensuring broad societal acceptance. This includes deeper insights in processes of societal engagement as well as aspects of socio-ecological justice and considerations of sufficiency concepts and just transition.

The proposed renaming of the title to “Nature-, environmentally and socially friendly energy transition” thus more accurately reflects the critical role of participation in democratic processes. In sustainability transitions, where competing interests often arise, inclusive governance and transparent participatory processes are crucial to building trust, addressing social concerns, and ensuring that all societal groups are equitably involved in shaping the future energy system.

Such an integrative framing is fundamental for addressing potential target conflicts and identifying synergies across ecological, economic and social aspects, supporting a more holistic approach to sustainability.

Apart from this key outcome, the participants highlighted four main priorities in relation to the eleven key issues identified prior to the workshop:

First, “governance of NEFET (now NESFET)” is seen as a highly important key issue, with an additional priority on impact assessment and biodiversity-related aspects of the energy transition.

Second, the importance of “comparing scenarios” was underlined, particularly for improving policy making and there is a need for better understanding of mechanisms for resilience of energy infrastructure as well as the stability of renewable energy systems.

Third, in terms of the prioritized key issue “environmental effects of energy infrastructure” the participants highlighted the aspects of efficient assessment of environmental effects and upscaling.

Finally, the key issue of “land use” was highlighted not only as a thematic priority, but also as a platform for all CASRI themes. It is linked to the key issue of social justice and regional/spatial planning. Participants suggested “land use” as a top-topic due to its central relevance for EPAs.

4 Societal relevance of themes

This section presents a synthesis of the insights obtained through the content analysis and the feedback obtained at the transnational workshop on the positioning of knowledge needs under the considered political priorities.

4.1 Security

The workshop discussions highlighted that the concept of security has become popular and expanded beyond traditional military concerns to encompass societal, environmental, and resource-based dimensions. For example, the 'resilient, net-zero, circular production systems' theme ranked the need to address security of resource supply on the industrial ecosystem level as the highest for the theme. This broader framing reflects a shift from resilience as a guiding principle to security as a more politically charged and strategic concept. The shift emphasizes that technical and societal security are deeply connected. Further, environmental risks—such as droughts, floods, and soil degradation—pose direct threats to social stability and economic well-being. These risks are compounded by geopolitical tensions, climate change, and resource dependencies, particularly in the context of international supply chains. As such, energy and resource security should be addressed through integrated, cross-sectoral approaches that consider both local vulnerabilities and global interdependencies.

The highly ranked key issues of the `sustainable urbanisation` theme, for example, explore various scales of interventions to address climate change risks. From creating green spaces, to technical climate adaption, all the way to realizing robust and sustainable construction projects: security from the risks posed by climate change requires innovation and research on building and greening initiatives. Further, understanding the combination of measures is also a viable research priority. As various territorial levels and various target groups could be involved, the aforementioned topics could be taken up by the transnational commons.

Nature-based solutions offer promising pathways for enhancing both security and sustainability. From coastal flood protection to urban mining and land restoration, these approaches can reduce vulnerability while delivering co-benefits for ecosystems and communities. However, their success depends on social acceptance, cost-effectiveness, and appropriate incentives—areas where more research and policy support are needed. The social dimension of security was also considered important. Climate adaptation, migration, and regional emergency planning all have profound implications for social resilience and well-being.

4.2 Democracy and participation

In the rapidly evolving and partly unpredictable landscape of democracy and participation, R&I must grapple with a complex web of societal, institutional, and communicative challenges. A key need emphasised by the participants is to ensure social justice and equity, particularly as solutions like electric vehicles remain inaccessible to many. Transitions risk deepening existing inequalities unless participation is broadened and made more inclusive.

Whereas the highly ranked key issues from the `resilient, net-zero and circular production systems` theme assumed issues related to democracy and participation to be important, there was difficulty seen in the operationalizing of these terms. Instead, it was discussed to focus on the strategic behaviour of specific actors. Similar conclusions regarding governance can be found from the `nature and environmentally friendly energy transition` theme considerations. This may be useful perspective for the transnational commons, namely noting the importance of transdisciplinary and participatory research, including knowledge co-design. Engaging with the public through transparent, emotionally resonant, and participatory methods is a special opportunity for EPAs. This also means fostering consensus-seeking mechanisms that prioritize shared understanding over compromise or confirmation. For the `sustainable urbanisation` theme, a possible innovative topic for research with important connections to the roles and competencies of the EPAs is co-design for urban greening initiatives and understanding of social vulnerabilities. Being public institutions with mandates to define their role and duties, it is possible to see how issues of social relevance may relate to the underlying principles of the EPAs (protection of environment for all, supporting of the common good, etc.). Such understandings of operationalizing may further support topics of transnational commons.

The importance of societal trust and transparency was emphasised. The results of research projects that are financed with taxpayers' money should be publicised to a greater extent so that the benefits are also clear to the public. However, in an era of widespread disinformation and misinformation, simply providing information is no longer enough. Institutions such as EPAs must go beyond data dissemination to foster trustworthy, evidence-based communication that resonates emotionally and is accessible to diverse audiences. This includes translating complex data into narratives that evoke understanding and engagement. EPAs and similar institutions should also embrace long-term thinking and look beyond their traditional silos, integrating transdisciplinary approaches and engaging with local, indigenous, and experiential knowledge to better anticipate systemic impacts.

4.3 Regulatory efficiency and competitiveness

The workshop discussions highlighted that proving regulatory efficiency and fostering competitiveness in the context of sustainability transformation requires a strategic rethinking of governance structures, tools, and incentives. At the core is the need for smart, adaptive regulation that supports innovation while reducing unnecessary administrative burdens. Importance of simplification and clarity was emphasised. Regulations should be designed with actionable rules, especially for funding instruments, to reduce uncertainty and encourage long-term innovativeness. This includes better ex-ante and ex-post impact assessments, identifying harmful, outdated or even redundant regulations, and ensuring that new rules are not only effective but also easy to implement.

Thoughtful use of digital tools and AI can offer some potential to streamline bureaucracy and enhance information processing. EPAs should build internal capacity to harness these tools effectively, while also ensuring precaution and regulatory innovation, and testing and refining new approaches with controlled experiments.

Multi-level governance is essential. Principles of the EU, for example those such as subsidiary and proportionality, are of key concern when considering the European level of integration for specific issues. Both are key when it comes to understanding the integration of land use as a European issue, for example. A balanced approach that combines EU-wide frameworks with local knowledge can enhance both efficiency and legitimacy. Societal learning and cross-disciplinary collaboration—involving legal, environmental, social, and economic expertise—are needed. Understanding who benefits from regulation, and how, is key to ensuring that policies are not only efficient but also just and inclusive.

The vision behind regulatory efficiency must be clear: governance should enable transformative change, not merely reduce costs. This means aligning regulation with long-term sustainability goals, while also ensuring co-benefits for society, industry, and the environment. The regulation paradox—where too streamlined regulation becomes more costly over time—underscores the need for proactive, forward-looking policy design.

Within the `sustainable urbanisation` theme, the importance of integrated regulation is stressed. On the one hand there are established cooperation between expert fields (such as land use and mobility) which can be built upon with dedicated research, as well as more open areas of cooperation less explored to this day. Especially in the later case, it should be a task to identify the specific thematic competencies of EPAs suitable for new cooperation with each other transnationally. The discussion at the workshop stressed that the key issue “integrated urban planning” can be seen as a method with which to relate existing EPA competencies with each other, ideally in new and novel ways. Also, the `biodiversity & climate` theme came to the conclusion that more focus on the interactions of environmental challenges for the topics of biodiversity and climate could be fruitful for transnational commons. Such an integrative framing is fundamental for addressing potential trade-offs and synergies between various issues and scales and for pursuing sustainability goals in a holistic manner.

Further, there is a role of EPAs in possibly leading or guiding a normative stance on regulation for standards. This was at least a consideration from the `resilient, net-zero and circular production systems` theme. This highlights the importance of having a clearer picture as to what regulation is to be optimized and for what system. For some themes this was possible to identify, such as the `biodiversity & climate` theme which pointed to identified knowledge needs related to effective climate policy. For other themes the regulatory situation is comprehensive and laden with various aims. It should be a future task of the theme lead and CASRI partners to identify which regulations are relevant for transnational commons and what research could provide insight into innovative key issues, keeping in mind the general agreement on an integrated approach mentioned above.

4.4 Digitalisation

Notwithstanding specific developments on sectoral policy level that drive digitalisation in processes, the group work discussions emphasised needs related to advanced monitoring and data utilisation. Digitalisation enables the collection, integration, and analysis of vast datasets—from energy use to habitat monitoring. However, digitalisation was also considered as too wide-spanning theme to be tackled by ES R&I. The `nature and environmentally friendly energy transition` theme for example highlighted the need to better integrate and consider scenarios development to guide sustainable development. How this is exactly achieved can be subject to transnational cooperation.

Data deluge was noted as a specific problem. The sheer volume and variety of data challenge agencies to develop systematic, integrative, and user-friendly approaches to data processing and interpretation. The ability to ask the right questions—what some call the “wisdom gap”—is becoming more critical than the ability to collect data itself.

For EPAs, digitalisation represents both a transformative opportunity and a complex challenge. As digital tools become increasingly embedded in environmental governance, the focus should shift from mere adoption new technologies to purposeful, ethical, and effective development. One of the most pressing needs is capacity building. Agencies must attract and empower more “digital natives” who are fluent in emerging technologies and can bridge the generational gap in digital literacy. This is essential not only for internal efficiency, but also for maintaining relevance in a fast-evolving digital landscape.

Digitalisation also raises questions of equity and accessibility. Tools, monitoring and data must be designed with users in mind—ensuring they are not only technically robust but also fair, transparent, and inclusive. This includes standardising data across countries, promoting open science, and ensuring that digital tools serve real-world needs, such as mapping biodiversity or supporting local decision-making.

There is a tension between using digital tools for sustainability and ensuring the sustainability of digital systems themselves. This dual perspective is crucial as agencies navigate the environmental costs of digital infrastructure. From the energy consumption of AI to the risks of over-reliance on models and generative AI, digitalisation must be approached with caution. EPAs must safeguard data access, ensure long-term storage, and uphold principles like “Do No Significant Harm” (DNSH). Ethical frameworks are vital for guiding responsible digital transformation.

The `biodiversity & climate` theme in particular highlighted the integration of considerations of social systems and participation (e.g. organisational, social, and behavioural change) on the one hand and improved utilisation of data on the other. Concretely mentioned was drawing on tools such as artificial intelligence, participatory citizen science, vision building, and awareness-raising initiatives. In relation to biodiversity, priority was placed on knowledge needs concerning comprehensive, up-to-date, and policy-relevant ecosystem monitoring. Transnational commons can thus be informed by a more robust data basis, if it is understood how these can be achieved and what aims they are to serve.

5 Summary and outlook

This report synthesizes and evaluates suggestions for environmental and sustainability research and innovation priorities, collected across 14 European national and regional contexts by the CASRI project. The aim is to identify relevant themes and potential key issues that address systemic, actionable, and transversal knowledge needs, taking into account societal relevance, the ability to contribute to grand challenges, and future responsiveness.

The CASRI project gathered expert views on knowledge needs and gaps, focusing on four predefined themes of environmental and sustainability research and innovation, while also welcoming new perspectives. The themes included: Resilient, net-zero, circular production systems; Biodiversity and climate; Sustainable urbanisation; and Nature- and environmentally friendly energy transition.

In total, over 600 individual proposals for priorities were collected. This report analyses the proposed priorities and identifies higher-level key issues that are relevant beyond individual countries. Based on content analysis, key issues were formulated and sorted using the guiding principles of CASRI. This initial selection was further discussed and validated in an international expert workshop consulting 60 participants of 47 different organisations.

The following aspects relevant to the future research and innovation agenda are emphasized under the four CASRI themes that organised the data collection:

- **‘Resilient, net-zero, circular production systems’**: No single common pattern could be identified across the participating CASRI case studies on a thematic level, with countries expressing distinct but different needs all around Europe. In general topics related to industry-oriented resilience and innovation (covering risk avoidance, autonomy and competitiveness) raised more diverse knowledge needs (i.e. systemic, transversal and actionable combined) on a national level than other key issues although the differences were marginal. In a transnational context, experts validated the national level results for the security & competitiveness oriented key issues, but promoted more system-wide public innovations under ‘democracy & participation’ to a higher level.
- **‘Biodiversity & Climate’**: The results indicate that both climate change and biodiversity are already well-established domains in science and policy, necessitating specific attention to their intersection. One potential approach is to address the climate–biodiversity nexus through the lens of restoring and enhancing the resilience of water and forest ecosystems, which were frequently mentioned. Despite the overall framing that highlights the connections between these key environmental challenges, and the broad recognition of their interdependencies, most proposed research priorities focused on either climate or biodiversity individually. This may be attributed to the strong research traditions in both fields and the composition of respondents, who may have had expertise in one area more than the other. The findings may reflect the challenges of building truly interdisciplinary research and innovation agendas capable of bridging or integrating well-established streams of environmental science. Interestingly, the relatively high proportion of proposed priorities focusing on issues beyond climate, biodiversity, or their interactions suggests potential for novel directions—driven by thinking that seeks to create new perspectives rather than merely developing or converging existing research streams.

- **'Sustainable Urbanisation'**: Sustainable urban development requires a multifaceted research and innovation agenda that addresses environmental, social, and economic dimensions. A priority is enhancing urban resilience through green infrastructure and nature-based solutions. Research is needed to support stakeholder coordination and to provide compelling evidence for decision-makers to invest in green infrastructure that improves urban well-being and climate adaptation. In terms of spatial planning and mobility, research should support sustainable land use and transport integration, including developing scenarios that span from building sites to regional scales. Social dimensions are also critical. Research should explore social equity, participatory governance, and sustainable lifestyles, particularly in relation to car dependency and inefficient land use. There is a call for better understanding and operationalisation of social innovation, inclusive participation, and co-design processes to ensure democratic and transformative urban governance. A cross-cutting research need is to identify synergies across issues such as biodiversity, well-being, and risk reduction, and to explore the transferability of successful approaches across different urban contexts.
- **'Nature and Environmentally Friendly Energy Transition'**: While the energy transition is well-established in both scientific and political discourse—particularly in technological terms—greater attention should be paid to its environmental and social impacts. These transnational common priorities reflect a shared commitment to balancing the nature-friendly and social dimensions of the energy transition, aiming for a sustainable and socially just future. Effective coordination among stakeholders, especially at the regional level, is essential. The energy transition field prioritises the integration of expert advice to resolve target conflicts and ensure regulatory compliance. At a transversal level, coordination across stakeholders—spanning various responsibilities and governance levels—can help shape and inform research agendas. Action requires shared knowledge on how to scale up a nature, environmentally and socially-friendly energy transition. The role of digitalisation, artificial intelligence, and decentralised energy systems also emerges as critical in enabling a more flexible and resilient energy infrastructure.

Several priorities were also presented outside the four predefined themes. Key issues identified beyond the original themes included integrative assessments of trade-offs, synergies, and risks—thus emphasizing preparedness; the management of geopolitical and other conflicts; environmental and ecosystem health; the potential for scaling up experiments; and innovation diffusion. The creation of policy-relevant understanding of transformative change and the role of the social sciences was also emphasized. Additionally, the reconfiguration of the economic system—highlighting overconsumption of natural resources, sufficiency and justice—was brought forward.

Overall, this report provides a comprehensive synthesis of shared transnational environmental and sustainability key issues. Simultaneously it places the reported key issues in the context of current perceived public priorities, such as security, democracy and participation, regulatory efficiency & competitiveness and digitalisation. As such, it delivers the analytical foundation for selecting issues with strategic potential for European transnational collaboration. The findings will significantly inform the development of the CASRI Strategic Research and Innovation Agenda.

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