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INTEGRATING POLICY AGENDAS FOR SUSTAINABLE INNOVATION: A QUADRUPLE HELIX APPROACH TO THE EUROPEAN GREEN DEAL AND SUSTAINABILITY TRANSITIONS

MONIKA POPPER

RAFAEL POPPER

CARINA ALEJANDRA RAPETTI

JOSEP MIQUEL PIQUE

ABSTRACT

This paper explores the integration of DIY (Do-It-Yourself) and crowdsourcing-driven innovation management with top-down policy frameworks to advance the European Green Deal and sustainability transitions. Drawing on the CASI (Common Framework for the Assessment and Management of Sustainable Innovation) project, it examines how CASI-F and its CASIPEDIA platform — a repository of over 700 sustainable innovation initiatives — can bridge local and global sustainability goals. Using a quadruple helix approach, the study highlights the role of innovation ecosystems in driving systemic change through the alignment of technological, economic, social, and environmental objectives. The paper compares the CASI SI agendas with the European Green Deal and sustainability transition agendas, identifying synergies, gaps, and opportunities for further alignment. Foresight is emphasised as a crucial tool to ensure innovation strategies remain adaptable, future-oriented, and resilient to emerging challenges. The findings underscore the importance of integrating grassroots innovations into broader policy frameworks to enhance sustainability transitions. Lastly, the paper recommends strengthening the Green Deal by fostering innovations from diverse actors, including those from the quadruple helix, and promoting the application of SMART foresight processes.

KEY WORDS

sustainability transitions, innovation ecosystems, European Green Deal, crowdsourcing-driven innovation, quadruple helix, sustainable innovation (SI) agendas, foresight methodology, climate-neutral future

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INTRODUCTION

The CASI project, which concluded in 2017, laid the foundational groundwork for significant contributions to sustainable innovation across Europe through its sustainable innovation (SI) agendas. Although the

project itself has now ended, CASI-F and its associated tools, such as the CASIPEDIA mapping platform, continue to attract users, with over 100 new SI cases added annually by a growing community of SI enthusiasts (Martini et al., 2020a). This sustained engagement with CASI-F, coupled with its increasing adoption across Europe, provides the impetus for this

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Monika Popper

Futures Diamond Ltd,
9 Bold Street, Warrington, WA1 1DN,
Manchester, United Kingdom
ORCID 0009-0000-7138-0002

Smart Society Research Group,
La Salle – Ramon Llull University,
Sant Joan de La Salle 42,
08022, Barcelona, Spain

Corresponding author:
e-mail: monika.popper@futuresdiamond.com

Rafael Popper

Faculty of Mechanical and Industrial
Engineering, Warsaw University
of Technology, 02-524 Warsaw, Poland
e-mail: Rafael.Popper@pw.edu.pl

Smart Society Research Group,
La Salle – Ramon Llull University,
Sant Joan de La Salle 42,
08022, Barcelona, Spain
e-mail: Rafael.Popper@salle.url.edu

Alliance Manchester Business School,
The University of Manchester,
Oxford Rd, Manchester M13 9PL,
United Kingdom
e-mail: Rafael.Popper@manchester.ac.uk
ORCID 0000-0002-4653-4994

Carina Alejandra Rapetti

Smart Society Research Group,
La Salle – Ramon Llull University,
Sant Joan de La Salle 42,
08022, Barcelona, Spain
ORCID 0000-0001-6423-7478
e-mail: Carina.Rapetti@salle.url.edu

Josep Miquel Pique

Smart Society Research Group,
La Salle – Ramon Llull University,
Sant Joan de La Salle 42,
08022, Barcelona, Spain
ORCID 0000-0002-0215-0139
e-mail: jm.pique@salle.url.edu

paper. In particular, the aim of this paper is to reanalyse the 10 CASI SI agendas within the context of the sustainability transition agendas and the European Green Deal agendas, with a particular focus on identifying commonalities, unique features, and synergies between these agendas. The CASI SI agendas, developed through a bottom-up, empirical approach, offer valuable insights into crowdsourcing-based innovation initiatives that have emerged across Europe. These initiatives are deeply rooted in local communities, businesses, and civil society, emphasising community-driven efforts, local knowledge, and practical solutions that are tailored to specific regional contexts. The ongoing application of CASI-F and its platform further underscores the relevance of these agendas in driving innovation processes, effectively bridging the gap between local, bottom-up innovation and broader sustainability goals.

Foresight plays a crucial role in connecting local innovation with broader sustainability goals. As positioned by Popper (2008), foresight is a systematic and methodologically rigorous process requiring careful design and implementation. This complexity necessitates its thoughtful integration into policymaking, ensuring that sustainable innovation agendas are both analytically grounded and adaptable to emerging challenges. Foresight is a participatory, prospective, and policy-oriented process that actively engages key stakeholders through environmental and horizon scanning techniques, aiming to anticipate, recommend, and transform (ART) futures across technological, economic, environmental, political, social, and ethical (TEEPSE) dimensions (Popper, 2011). This participatory and forward-looking nature makes foresight an essential tool for guiding long-term sustainability transitions, especially within the framework of the European Green Deal, where it informs policy decisions that address the interconnected challenges of achieving a climate-neutral future.

In contrast, the European Green Deal, initiated by the European Commission, represents a top-down, policy-driven framework that sets out ambitious targets for climate neutrality by 2050. It identifies strategic actions across key sectors such as energy, transport, agriculture, and biodiversity, with the aim of catalysing systemic transformation across Europe. Similarly, the sustainability transition agendas focus on understanding the political, social, and economic drivers and barriers of sustainability transitions, offering a comprehensive theoretical framework for facilitating transformative societal change. While these top-down and theoretical agendas are critical in guiding Europe's

overarching sustainability strategy, their effectiveness relies on deeper integration with local-level innovations to achieve tangible results on the ground.

This paper compares these three sets of agendas, focusing on how the crowdsourcing-driven CASI SI agendas can complement and enhance the policy-driven frameworks of the European Green Deal and the research-focused sustainability transition agendas. By examining areas of alignment, identifying gaps, and exploring opportunities for further development, the analysis offers a novel perspective on how local innovations and top-down policies can be aligned to accelerate sustainability transitions. Moreover, mapping initiatives such as CASI-F and its CASIPEDIA platform are instrumental in understanding the intersection of bottom-up and top-down efforts. As Popper (2009) asserts, "Foresight research is not only interdisciplinary in theory but also in practice", emphasising the importance of mapping platforms that facilitate interdisciplinary connections and promote collaboration across sectors. These initiatives play a pivotal role in ensuring that local innovations are effectively mapped and integrated into broader policy frameworks, fostering synergies that can drive sustainable development.

An additional purpose of this paper is to demonstrate the importance of tools like CASIPEDIA as an instrument for capturing and disseminating crowdsourcing-based innovations. By leveraging CASI-F and its ever-expanding database of sustainable innovation initiatives, CASIPEDIA offers valuable insights into successful local projects, enabling their integration into broader policy frameworks. The potential of such tools for fostering interdisciplinary collaboration and advancing sustainability transitions in Europe cannot be overstated. Ultimately, the paper aims to illustrate how the continued use of CASI-F, underpinned by SMART foresight principles, can support a more integrated and inclusive approach to achieving Europe's climate-neutral goals. This approach ensures that systemic change is both actionable and widely supported, paving the way for a more sustainable and inclusive future across Europe.

1. LITERATURE REVIEW

1.1. INNOVATION ECOSYSTEMS: CATALYSTS FOR SYSTEMIC CHANGE

Innovation ecosystems are increasingly recognised as pivotal drivers of systemic change, particu-

larly within the context of sustainability transitions. These ecosystems are dynamic networks of interconnected actors — governments, businesses, research institutions, and civil society — that collaborate to address complex, cross-cutting challenges. By facilitating the flow of knowledge, resources, and technology, innovation ecosystems have the potential to instigate transformative shifts across various sectors. The concept of systemic change, or transformation, is a fundamental principle of sustainability science. It involves far-reaching shifts across economic, technological, and social systems, enabling societies to effectively respond to global challenges such as climate change and resource depletion. Unlike incremental changes that refine existing systems, systemic change necessitates the complete rethinking and redesigning of these systems. Achieving such transformation requires a realignment of policies, practices, and institutional frameworks to align with sustainability objectives. As Kivimaa and Kern (2016) suggest, transitions involve not only the development of disruptive innovations but also the formulation of policies designed to drive broader changes within socio-technical systems. This underscores the critical role of integrating technological innovation with policymaking to facilitate large-scale transformations. It is through the strategic alignment of these elements that societies can navigate the complexities of sustainability transitions and achieve meaningful change.

Within this context, innovation ecosystems serve as the driving force behind systemic shifts, enabling the scaling of sustainable innovations by integrating technological advancements with new governance models, business practices, and societal norms. An innovation ecosystem is the evolving set of actors, activities, and artefacts, and the institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors (Granstrand & Holgersson, 2020). This dynamic and evolving nature is crucial for facilitating the innovation required for sustainability transitions, and these ecosystems can compete with or complement each other (*ibid.*). This is particularly relevant for the European Green Deal, which spans sectors like energy, transport, agriculture, and industry, requiring collaboration and competition to drive technological solutions for sustainability. As Oh et al. (2016) highlight, innovation ecosystems are purposefully designed and engineered systems aiming to achieve specific goals, such as sustainability transitions, rather than evolving naturally. They thrive on the balance of

competition and collaboration, ensuring that diverse actors both cooperate and compete to drive innovation. Furthermore, the era of the *laissez-faire* approach to market development is over, and today's complex challenges necessitate active governance and intervention to align innovation with sustainability objectives. This shift requires clear policy frameworks that guide and regulate the ecosystem's development, ensuring that market dynamics support the overarching goals of the European Green Deal.

Transitions encompass changes both across value chains and within each part of them, highlighting the need for multi-dimensional transformations in technological and societal structures (Markard & Truffer, 2008). Furthermore, the innovation systems approach provides greater analytical power by examining the structural and functional dynamics within these ecosystems, offering valuable insights into how different actors collaborate and navigate complex challenges. A key feature of these transitions is the fostering of competition among diverse suppliers, which in turn can stimulate market-driven solutions that enhance efficiency and effectiveness in addressing sustainability goals. The innovation ecosystem concept emphasises both collaboration and competition, offering a more holistic and nuanced understanding of how innovation ecosystems function. The European Green Deal could greatly benefit from supporting such a variety of technological solutions rather than focusing on a single pathway, as this diversity fosters more robust and adaptive innovation ecosystems.

A key characteristic of successful innovation ecosystems is their ability to effectively address the interdependence between various actors. As highlighted by recent studies on ecosystem dynamics, the challenges faced by different stakeholders — from technology developers to end-users — are distinct yet deeply interconnected. The challenges in upstream components, such as those faced by suppliers and technology developers, are qualitatively different from those faced by downstream complementors who enable customers to fully utilise new innovations. For example, innovations in clean energy technologies may require not only advances in the core technology itself but also changes in infrastructure, such as energy grids or charging stations, which are essential for their widespread adoption (Adner & Kapoor, 2010).

In the context of the European Green Deal, these distinctions are particularly relevant. Achieving sustainability requires more than just technological breakthroughs; it also requires systemic changes in

how innovations are integrated into existing societal and economic systems. This means addressing not only the internal innovation challenges within firms but also considering how the surrounding ecosystem — including suppliers, regulators, and customers — must evolve to support these innovations. Understanding the structure of technological interdependence in such ecosystems allows for better identification of the barriers to scaling sustainable solutions and formulating policies that target these bottlenecks (Adner & Kapoor, 2010).

As the focus shifts from individual innovations to broader systems of collaboration, it becomes clear that successful sustainability transitions depend on the alignment of diverse actors across sectors. The European Green Deal provides a framework to address the interconnected challenges of climate change, biodiversity loss, and inequality, offering an opportunity to foster the kind of multi-stakeholder collaboration needed for systemic change. This approach moves beyond firm-level innovation and highlights the importance of a broader, more inclusive ecosystem perspective, which enables technology evolution and creates pathways for achieving long-term sustainability goals.

1.2. EUROPEAN GREEN DEAL (EGD): A FRAMEWORK FOR COLLABORATION

The European Green Deal (EGD), launched in 2019, presents an ambitious roadmap to make Europe the world's first climate-neutral continent by 2050. Central to this vision is a commitment to reducing greenhouse gas emissions across key sectors such as energy, agriculture, transport, and industry while addressing the profound challenges posed by climate change. However, the success of this transition depends on its inclusivity and the ability to mitigate social and economic impacts, particularly for vulnerable regions and workers. The European Commission (2019a, 2019b, 2020) highlights the importance of addressing these inequities through mechanisms like the Just Transition Fund and Mechanism, which aim to mobilise at least EUR 100 billion to support the regions and sectors most affected by the green transition. Despite these efforts, concerns remain regarding the adequacy of the EGD's focus on social sustainability and equity, which are often overshadowed by decarbonisation goals (Hereu-Morales et al., 2024; Kwilinski et al., 2024)).

A key element of the EGD is its emphasis on systemic innovation, calling for an integrated, cross-

sectoral approach that fosters synergies between technologies, policies, and societal practices. This vision requires the development of robust innovation ecosystems that enable multi-stakeholder cooperation, knowledge exchange, and the scaling of sustainable solutions. By facilitating the integration of sustainable practices across sectors such as energy, transport, and agriculture, the EGD envisions the transformation of economic systems prioritising sustainability. However, for a truly just and inclusive transition, this transformation must also address the social and economic dimensions of sustainability (Koundouri et al., 2024). Despite its ambitious goals, the EGD has been criticised for insufficiently incorporating policies to tackle inequalities, poverty, and social justice, even though these are closely linked to environmental sustainability.

The EGD is often described as a collection of evolving targets, intentions, and objectives rather than a fixed strategy, reflecting the complexity and long-term nature of the transition. This dynamic approach acknowledges that policy implementation and societal adaptation will unfold over decades. Thus, the development of innovation ecosystems that bridge the gap between advanced technologies and their real-world applications is crucial. These ecosystems will play a vital role in advancing clean energy, sustainable mobility, and circular economy practices, with initiatives like Destination Earth (DestinE), which creates a digital simulation of Earth to better understand climate impacts, offering essential tools for decision-making and policy development.

To ensure the EGD delivers on both its environmental and social promises, it is critical to develop innovation ecosystems that extend beyond technology to include social innovation. These ecosystems must promote collaboration across all sectors of society, ensuring that no one is left behind in the green transition and that the benefits of sustainable growth are shared equitably. As Szélpál and Varga (2024) emphasise, such collaborative frameworks are essential for fostering both environmental and social sustainability, ensuring that the EGD's ambitions are met comprehensively. A key aspect of the Green Deal's success is its focus on energy independence and security, reducing Europe's reliance on energy imports from politically unstable regions. By promoting renewable energy sources like wind and solar power, the EGD not only contributes to decarbonisation but also enhances Europe's economic competitiveness and political stability. Furthermore, the transition to a circular economy, which replaces the

traditional linear model of resource use, is integral to decoupling economic growth from resource consumption, supporting the EGD’s target of net-zero emissions by 2050. This focus on systemic innovation ensures a sustainable and economically viable transition. Additionally, the Green Deal’s financial mechanisms, such as NextGenerationEU (NGEU) and green bonds, provide critical support for achieving climate and sustainability targets, with investments directed towards long-term resilience. In this context, initiatives like the “Fit for 55” package, which seeks to reduce net greenhouse gas emissions by at least 55% by 2030, must be viewed as part of a broader effort to create a just, inclusive, and resilient European economy. Achieving this requires integrating measures to address inequalities, promote decent work, and support communities most affected by the green transition. Only by addressing the full spectrum of sustainability — environmental, social, and economic — can the EGD be realised as a transformative framework, positioning Europe as a global leader in sustainable development.

2. RESEARCH METHODS

This study adopts a mixed-methods approach, combining both qualitative and quantitative datasets to assess the role of innovation ecosystems in advancing the objectives of the European Green Deal. The methodology draws upon the CASI project, a European Union-funded initiative that systematically mapped and analysed over 500 sustainable innova-

tion cases across Europe. The study compares the ten CASI sustainable innovation (SI) agendas with the European Green Deal and sustainability transition agendas to identify synergies and gaps that could guide more effective sustainability transitions.

2.1. LITERATURE REVIEW AND DOCUMENTARY ANALYSIS

The first step of the methodology involved an extensive literature review and documentary analysis. This was critical in establishing a comprehensive understanding of the theoretical frameworks and policy directions relevant to the study. The European Commission’s reports and communications about the European Green Deal were examined to identify the core objectives, priorities, and planned actions within the Green Deal. This involved a detailed review of key documents such as the European Green Deal Communication (European Commission, 2019a, 2019b), the Climate Law, and the Green Deal Implementation Plan (European Commission, 2020). These documents provided crucial insight into the EU’s strategic plans for achieving climate neutrality by 2050, focusing on decarbonisation, resource efficiency, and technological innovation.

Additionally, the sustainability transitions (ST) agendas outlined in Köhler et al. (2019) were reviewed to understand the academic perspectives on the dynamics of sustainability transitions. This framework, which examines the role of power, governance, social movements, and institutional transformations, was crucial in contextualising the CASI SI agendas

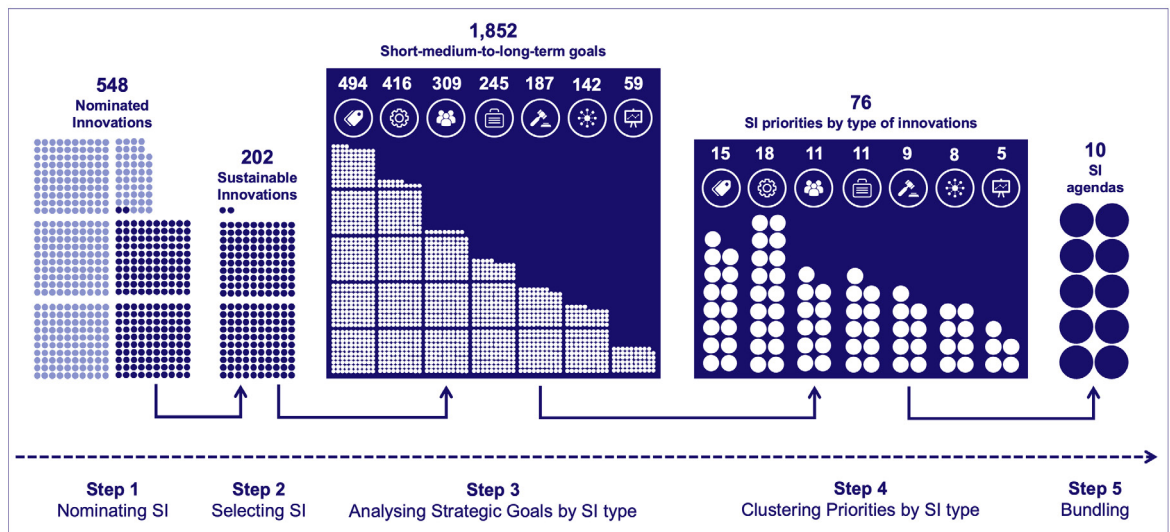


Fig. 1. From 1,852 quadruple helix innovation goals to ten sustainable innovation agendas

within broader theoretical discussions on systemic change.

The SI agendas themselves are based on a review of key documents, including CASI-F and the CASI project's comprehensive reports on sustainable innovation mapping and policy advice, which outline the core principles for fostering crowdsourcing-based innovation assessment and management (Popper et al., 2017a, 2017b, 2017c).

2.2. DATA COLLECTION

During the life of the CASI project (Popper et al., 2020; Martini et al., 2020b; Velasco et al., 2020), the CASI team, consisting of 19 partners from 12 EU countries and 16 country correspondents, nominated a total of 548 initiatives, each country representative selecting 15–22 initiatives to ensure broad coverage of the pre-defined seven types of sustainable innovation (SI) and public participation, as well as engagement with the quadruple helix of stakeholders. Of the nominated initiatives, 49% were led by business actors, 21% by government entities (including inter-governmental organisations such as the EU and the UN), 20% by civil society organisations (including NGOs), and 10% by research and education stakeholders. These initiatives focused on social, economic, and environmental dimensions and aligned with one or more EU Framework Programme for Research and Innovation priorities related to climate action, environment, resource efficiency and raw materials while spanning key sectors such as energy, agricul-

ture, mobility, and the circular economy, ensuring a diverse representation of local, regional, and national-level innovations (Popper et al., 2020). This diversity was vital for addressing sustainability challenges across Europe.

From this pool, 202 initiatives were selected from CASIPEDIA (Box 1) for detailed mapping and analysis based on criteria such as sustainability impact, public participation, scalability, and novelty. The aim was to capture innovations with substantial potential for societal impact, particularly at local and regional levels. These selected initiatives were analysed in terms of their main and supporting objectives, which were then clustered to identify key research and innovation priorities. A total of 1,852 short-, medium-, and long-term goals and aspirations of the quadruple helix of SI stakeholders were analysed, aimed at contributing positively to sustainability. These goals were derived from the different types of innovations, with 494 from product-related innovations, 416 from service innovations, 309 from social innovations, 245 from organisational innovations, 187 from governance innovations, 142 from system innovations, and 59 from marketing-related innovations (Popper et al., 2017a).

From these 1,852 goals, some 76 SI priorities were mapped against the seven types of SI, and these were subsequently clustered into ten sustainable innovation (SI) agendas (Fig. 2). The resulting key terms were carefully analysed and clustered into key SI priorities. Several research priorities per type of SI were formulated by clustering these terms, but only

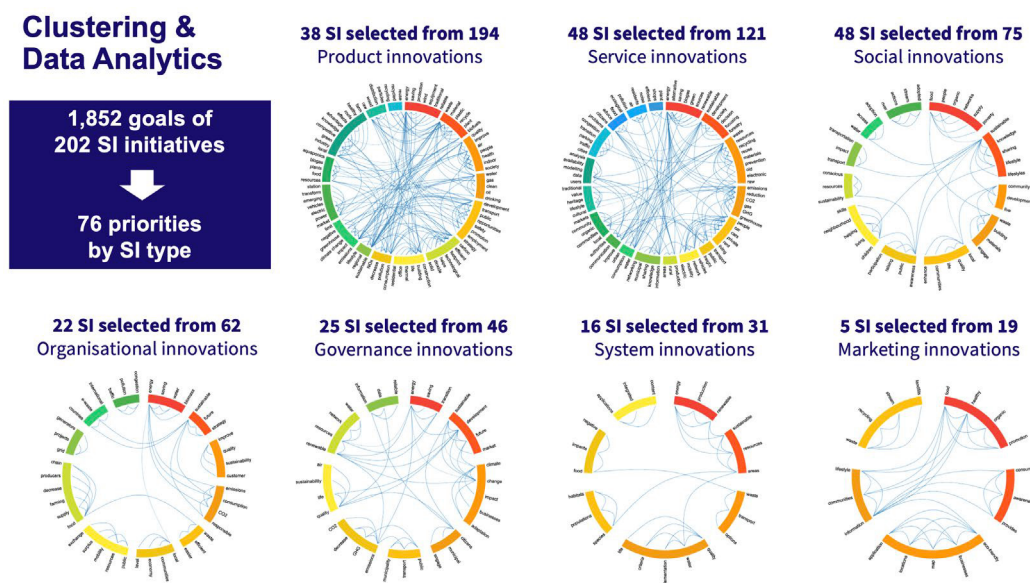


Fig. 2. From SI goals to SI priorities by type of innovation

the top five priorities from each type are discussed in this paper. These priorities were then linked to EU Framework Programme for Research and Innovation priority areas and relevant socio-economic sectors. It is worth noting that while some of the innovators' objectives have already been achieved and are driving positive environmental, economic, and social transformations, they remain as priorities for future developments and diffusion strategies of similar innovations. Thus, the combined analysis of SI objectives can be seen as the implicit, and at times explicit, ongoing and future research and innovation agendas of innovators (ibid.).

2.3. DATA ANALYSIS AND COMPARATIVE FRAMEWORK

The next step of the analysis involved identifying key sustainable innovation (SI) priorities across seven innovation categories: product, service, social, organisational, governance, system, and marketing. Qualitative and quantitative methods were employed to extract meaningful patterns and trends from the dataset. Text mining tools were used to identify recurring themes, while qualitative content analysis was employed to interpret and contextualise the data,

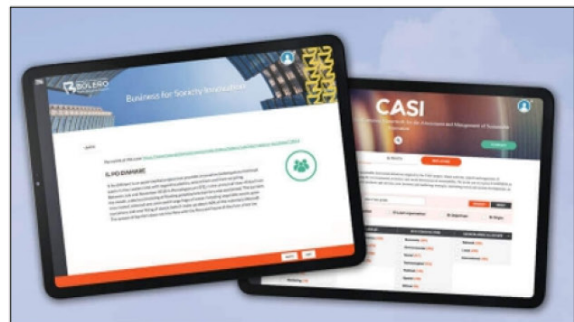
revealing the underlying connections and implications of these themes.

Once the key themes and trends were identified, a comparative analysis was conducted between the ten SI agendas, the sustainability transition agendas, and the European Green Deal agendas. This analysis focused on understanding the synergies between crowdsourcing-based innovation management and top-down policy frameworks. In particular, it aimed to identify potential gaps where further alignment or development might be necessary to ensure cohesive and inclusive sustainability transitions. The key themes from the SI agendas — including eco-community empathy, circular economy, and sustainable transport — were compared with the policy-driven agendas of the Green Deal and the research-oriented agendas of sustainability transitions.

A critical component of this analysis involved using the quadruple helix framework, which maps the roles of government, business, academia, and civil society across these sustainability agendas. Each agenda was assessed for the intensity and relevance of each stakeholder's role in driving its objectives. The comparative matrix highlighted how each stakeholder group contributed to advancing innovation and sustainability goals, focusing on areas such as govern-

By 2025, CASIPEDIA has become a unique repository of some 700 sustainable innovation initiatives, combining environmental, economic, and social dimensions of sustainability. This extensive database provides activists, experts, and sustainability advocates with access to a diverse range of innovative solutions, from new products and services to innovative business strategies, social developments, and emerging policies. CASIPEDIA's wide array of innovations enables stakeholders to explore practical solutions that address the most pressing global sustainability challenges.

- *Innovation types:* CASIPEDIA categorises innovations into seven types, with 36 % focused on products, 21 % on services, and 18% on social innovations. It also includes 10 % organisational innovations, 7 % governance-related solutions, 6 % system innovations, and 4 % marketing innovations.
- *Geographical scope:* The initiatives span diverse geographical contexts, with 41.79 % of innovations at the national level, 31.69 % local, and 26.52 % international in scope, ensuring a comprehensive global perspective on sustainable innovation.
- *Key areas:* The database prioritises global sustainability challenges with a focus on 36.48 % of initiatives aimed at resource efficiency, 31.03 % addressing climate action, and 25.07 % on raw materials. 7.41 % of the initiatives focus on environmental solutions.
- *Success factors:* CASIPEDIA captures the impact of innovations across multiple success factors, with 21.92 % emphasising economic impact, 21.86 % environmental, and 18.26 % technological advancements. Social and political success factors each contribute 18.26 % and 8.26 %, respectively, while spatial and ethical dimensions account for 6.09 % and 5.51 %.



Further access to CASIPEDIA is available online at <https://www.futuresdiamond.com/casi2020/casipedia/>.

Fig. 3. Box 1. CASIPEDIA — a comprehensive resource for sustainable innovation

ance, system innovation, and community-based solutions. This allowed for a nuanced understanding of how crowdsourcing-driven innovations and top-down policy initiatives can complement and reinforce each other, providing a comprehensive view of the innovation ecosystem and its role in achieving sustainability transitions.

2.4. BOTTOM-UP HORIZON SCANNING AND EXPERT INSIGHTS

As part of the methodology, a self-sustainability element was incorporated into CASI-F through the development of an openly accessible online tutorial designed to promote crowdsourcing-based sustainable innovation assessment and management (Box 2). This innovative, certified executive course represents an example of organisational innovation, introducing a novel approach to learning and applying CASI-F to real-world innovation cases. By providing widespread and unrestricted access to the course and enabling participants to map their own innovation cases into CASIPEDIA, a comprehensive database that aids users in organising and tracking sustainable innovations, the CASI project has established an open and scalable system for continuous innovation.

By 2017, the CASI project had successfully trained and certified 100 participants, meeting its initial target. However, the enduring relevance of the course and its accessibility via an online platform has resulted in sustained interest beyond the completion of the project. As of now, the course has expanded its reach significantly, with over 577 participants from 80 countries around the world. Countries such as Colombia, Poland, and Bulgaria lead in enrolment, underscoring the course's global accessibility and its capacity to foster bottom-up engagement in sustainable innovation practices. This growth in participation highlights the long-term impact and self-sustainability of CASI-F, ensuring its continued relevance in the absence of further EU funding since 2017.

The online tutorial and executive course form a crucial component of the bottom-up horizon scanning strategy, which generates new data for subsequent analysis through focus groups and expert insights. This approach encourages participants from a variety of sectors to contribute their innovation cases and challenges, providing a rich source of real-world data that feeds into the broader analysis. A diverse range of perspectives on local sustainable innovations is captured by engaging directly with

The Sustainable Innovation Assessment and Management course has achieved notable global participation, reflecting widespread interest in sustainability and innovation management across various regions. The distribution of participants highlights the course's reach beyond Europe, with significant engagement from Latin America, Asia, and Africa. Approximately 45 % of participants come from Europe, with countries such as Poland, Italy, and Portugal leading the way. The Americas represent around 30 %, with strong participation from Colombia, Peru, and Brazil. The remaining 25 % is spread across Africa, Asia, and Oceania, demonstrating the global relevance of sustainable innovation practices.

In terms of top participating countries, the course has seen the highest engagement from Colombia, which accounts for 19 % of total participants, followed by Poland (11 %) and Bulgaria (9 %). These three countries alone make up nearly 40 % of the course's total enrolment, showcasing the course's significant impact in these regions. Other countries with notable participation include Italy, Portugal, and Spain, contributing to the European dominance in course enrolment.

Top ten countries by participation:

- Colombia — 108 participants (19 %)
- Poland — 65 participants (11 %)
- Bulgaria — 54 participants (9 %)
- Italy — 43 participants (8 %)
- Portugal — 34 participants (6 %)
- Spain — 22 participants (4 %)
- Peru — 21 participants (4 %)
- Czech Republic — 19 participants (3 %)
- United Kingdom — 17 participants (3 %)
- France — 15 participants (3 %)



This broader geographical spread and the top countries reflect the enduring and expanding relevance of the course, contributing to its legacy of self-sustainability and its alignment with current global sustainability needs. With such widespread participation, the course continues to foster the development of sustainable innovation across borders, nurturing a community of practitioners equipped to address the pressing environmental and societal challenges of our time.

Further access to the CASI-F tutorial is available online at <https://www.futuresdiamond.com/casi2020/tutorial/>.

Fig. 4. Box 2. Global participation in the CASI-F course

crowdsourced participants, thereby enhancing the understanding of how these innovations evolve and align with broader sustainability objectives.

Furthermore, the methodology is supported by other types of innovation, such as social innovation and system innovation, particularly through the development of the BOLERO project (2022–2025). The BOLERO project is designed to adapt CASI-F to the needs of the University of Milano-Bicocca in Italy, offering a practical example of how system innovation can transform education and innovation management by linking local institutional needs with broader sustainability agendas. The BOLERO project serves as a sister mapping platform to CASIPEDIA, further advancing the integration of bottom-up approaches with the overarching goals of sustainability. It demonstrates how social innovation can be embedded into educational and research practices by encouraging collaborative, knowledge-sharing environments that enhance societal relationships and create new forms of collaboration within the university and beyond.

The focus groups formed as part of this methodology comprised stakeholders from local innovation ecosystems, including innovators, policymakers, and researchers, who discussed key findings from the SI agendas and their relevance to the European Green Deal. These discussions provided valuable insights into how innovations from local contexts can align with or challenge larger policy frameworks. Focus groups not only identified barriers but also highlighted enablers to the integration of local innovations with global sustainability objectives. Additionally, expert insights were gathered from leading researchers in sustainability transitions, policy advisors, and practitioners engaged in the European Green Deal. Their input provided a more nuanced understanding of the challenges and opportunities for sustainability transitions in Europe. These insights helped refine the analysis, offering perspectives on how top-down policy initiatives could better support the integration of bottom-up innovations, thus enhancing the scalability and impact of sustainable innovations across different levels. Through these combined efforts, a global community of innovators and researchers committed to sustainable change continues to grow.

2.5. COMPARATIVE ANALYSIS AND SYNTHESIS

The final phase of the analysis synthesised the findings from the SI agendas, the European Green Deal, and the sustainability transition agendas. This

synthesis aimed to develop a more integrated and inclusive approach to sustainability transitions, highlighting how the SI agendas, with their emphasis on community-driven innovation, could complement and strengthen the Green Deal's ambitious goals. The comparative analysis also identified specific areas of alignment, potential gaps, and opportunities for policy development, ultimately contributing to a more cohesive sustainability agenda that integrates local innovations with broader European objectives.

3. RESEARCH RESULTS AND DISCUSSION

The alignment between the CASI SI agendas, the European Green Deal, and the transitions research agendas – complemented by the guidance set out in Action Roadmaps for More Resilient Research and Innovation Futures – paves a shared pathway toward a climate-resilient, sustainable future (Popper & Popper, 2024, 2025). These three frameworks share common overarching objectives, including the reduction of greenhouse gas emissions, the enhancement of resource efficiency, and the promotion of sustainability across various sectors. By comparing and contrasting these agendas, this section highlights the synergies that can foster more integrated approaches for the implementation of the Green Deal (Szpilko & Ejdys, 2022). The identification of these commonalities not only reveals areas of alignment but also emphasises the significance of combining crowdsourced innovation management with top-down policy frameworks to drive systemic transformations. This analysis provides valuable insights into how local innovations, as outlined in the CASI SI agendas, can meaningfully contribute to the ambitious goals of the European Green Deal, ensuring that both local and global sustainability objectives are effectively pursued.

3.1. SYNERGIES FOR SUSTAINABILITY: A COMPARATIVE ANALYSIS OF KEY AGENDAS

This subsection presents a comparative analysis of ten sustainable innovation agendas, nine sustainability transition agendas, and ten European Green Deal agendas, focusing on their key areas of alignment. The five core themes explored — environmental sustainability and resource management; technological innovation and industrial transformation; social change, equity, and justice; governance, policy, and institutional transformation; and integra-

tion of sustainability across sectors — serve as the foundational pillars through which these agendas intersect. Examining the synergies between these three frameworks uncovers the potential for a more integrated approach that combines bottom-up innovation with top-down policy frameworks. This comparative analysis not only clarifies the shared priorities of these agendas but also provides insight into how localised innovation efforts, as outlined in the CASI sustainable innovation agendas, can complement and reinforce the European Union's broader sustainability objectives. In doing so, it highlights the opportunities for a more coordinated and cohesive path toward a sustainable, climate-neutral future. The following analysis delves deeper into the converging themes across these agendas, illustrating how their collective strengths can be leveraged to foster long-term sustainability.

3.1.1. SUSTAINABLE INNOVATION AGENDAS

The ten sustainable innovation (SI) agendas presented here are based on previous work from the authors in the CASI project (Popper et al., 2017a; 2017b), though they have been revised and updated to reflect current challenges and emerging trends. These agendas focus on addressing urgent global issues through systemic, multidisciplinary approaches. They encompass the transformation of energy, transportation, and resource management while fostering resilience and innovation in governance and education. Promoting sustainable practices across sectors, they advocate for circular economies, renewable energy, and localised food systems, aiming to equip communities with the necessary tools for long-term sustainability.

1. Tackling climate change and reducing greenhouse gas emissions agenda calls for innovative approaches to tackling climate change through systemic solutions at multiple levels. It advocates for a shift from viewing climate change as a problem to recognising it as an opportunity for broad societal transformation. Key strategies include the implementation of climate mitigation technologies, the promotion of low-carbon business models, and the integration of climate-resilient policies across sectors. R&I efforts should focus on creating adaptive, multi-level solutions that engage all sectors of society, empowering communities, and ensuring climate justice, while fostering collaboration across industries, governments, and citizens to accelerate the transition to a low-carbon future.

2. Enhancing governance through foresight and data-driven intelligence. In a world increasingly shaped by uncertainty and unpredictability, the need for anticipatory governance has never been more urgent. This agenda focuses on the integration of foresight methodologies, data analytics, and predictive intelligence into governance structures to better address sustainability challenges. By leveraging big data, artificial intelligence (AI), and scenario planning, it aims to create adaptive, responsive governance models that can navigate global shifts in climate policy, geopolitics, and socio-economic dynamics. The role of ICT and data-driven decision-making is crucial to enable governance that is proactive, flexible, and capable of responding to wild card events, such as policy reversals and climate commitments, ensuring long-term sustainability and resilience.

3. Building integrated sustainable infrastructures for a circular bioeconomy agenda focuses on developing sustainable urban and rural infrastructures that support a circular bioeconomy. Emphasising material efficiency, sustainable building practices, and the integration of smart technologies, it explores how infrastructure can reshape supply chains and consumption patterns. The role of governance and social innovation is crucial for scaling circular economy models, particularly in resource management. Future R&I should explore systemic approaches to creating connected economies, where sustainable technologies work in tandem with social, economic, and governance innovations to enhance resilience and reduce environmental impacts across diverse geographical and socio-economic contexts.

4. Advancing responsible environmental management and resource efficiency agenda focuses on balancing economic activity with environmental sustainability, particularly through resource-efficiency strategies. By adopting a systems approach, it addresses product innovations, governance models, and social innovations aimed at reducing emissions and managing resource consumption. It advocates for integrating circularity into industrial and residential systems, with a focus on water, energy, and waste. Moving beyond technical solutions, it calls for systemic, behavioural, and governance innovations that promote sustainable consumption and equitable distribution while also focusing on restorative approaches to natural ecosystems and promoting collaborative action for inter-sectoral sustainability.

5. Accelerating the transition to renewable energy and biofuels. The focus of this agenda is the transformation of energy systems towards sustaina-

bility, primarily through renewable energy and bio-fuel solutions. It addresses both supply-side innovations, such as biogas and anaerobic digestion, and demand-side strategies, such as energy efficiency and community energy initiatives. Future R&I efforts should focus on creating integrated energy systems, incorporating social and economic governance models that facilitate the transition. This agenda highlights the need for policies that support low-carbon technologies while also considering societal impacts, including equity in access to renewable energy, community involvement, and sustainable energy consumption practices.

6. Innovating sustainable transport and mobility systems agenda focuses on sustainable transport solutions, advocating for a shift towards low-carbon, accessible mobility systems. It examines innovations in transport technologies, such as electric and hydrogen vehicles, alongside social innovations that encourage shifts in behaviour and public engagement. The integration of smart technologies, such as big data and IoT, is central to optimising transport systems and promoting more sustainable urban planning. Future R&I should explore the tensions between technological advances, such as smart cities, and the social implications of mobility, including access, equity, and the challenge of reducing dependency on unsustainable transport models.

7. Advancing circular economy and waste resource management agenda promotes the transition to a circular economy where waste is viewed as a resource. It highlights the importance of systemic innovation across industries, focusing on circular business models, waste reduction, and recycling. Drawing from examples of both small-scale community-based initiatives and large-scale industrial symbiosis, it encourages scaling up successful models through improved infrastructure, financing, and design innovation. R&I efforts should address barriers to circularity, exploring solutions for product life-cycle management, waste-to-resource technologies, and the social dynamics of consumption to facilitate the transition to a sustainable, zero-waste economy.

8. Enhancing eco-community resilience and collaborative development agenda aims to foster sustainable, inclusive communities through empathy, solidarity, and local economic resilience. Emphasising multi-stakeholder engagement, it advocates for collaborative governance models that address gender, ethnic equality, and citizen empowerment. By leveraging digital platforms, this approach enhances local

development through crowd-funded initiatives, cooperative business models, and sustainable regional development. Additionally, it promotes environmental stewardship in both urban and rural settings. The focus is on enabling behavioural change, with empathy as a central driver, creating institutions that are socially, culturally, and ecologically responsive to long-term sustainability challenges.

9. Embedding sustainability in education and skills development agenda stresses the critical role of education in shaping a sustainable future. It advocates for incorporating sustainability into all levels of education, from primary schools to professional training, promoting both technical and behavioural change. The focus is on fostering skills that support sustainable practices in diverse sectors, from green technologies to community-based sustainability initiatives. Future R&I should explore the potential of online platforms, gamification, and eco-feedback systems to engage citizens, businesses, and policymakers. The aim is to create an informed, active populace capable of driving and participating in the transformation towards a more sustainable world.

10. Promoting sustainable agriculture and localised food systems agenda focuses on fostering sustainable agricultural practices that support both ecological health and food security. Emphasising local food systems, it encourages innovations in farming techniques, such as aquaculture and alternative cultivation practices, that enhance resource efficiency and reduce environmental impact. By promoting circularity in food production and distribution, it seeks to reconnect producers and consumers, encouraging sustainable consumption. Future R&I should explore scaling up successful local initiatives and identifying pathways to influence global food systems towards sustainability, addressing challenges such as public health, education, and the need for a post-oil food transition.

3.1.2. SUSTAINABILITY TRANSITION AGENDAS

The nine sustainability transition agendas presented here are based on collaborative work from the Sustainability Transitions Research Network (STRN), evolving from earlier research and discussions within the network (Köhler et al., 2019). These agendas have been revised to reflect the rapid growth and diversification of the field, addressing emerging global challenges. They focus on the complex, multi-dimensional nature of transitions, exploring the roles of governance, civil society, and industry in reshaping energy,

food, transport, and urban systems. The agendas advocate for transformative, equitable change, aiming to build resilient, sustainable societies through interdisciplinary and participatory approaches.

1. Understanding transitions — theoretical frameworks and insights agenda focuses on the foundational frameworks in sustainability transitions, primarily the multi-level perspective (MLP), technological innovation systems (TIS), strategic niche management (SNM), and transition management (TM). These frameworks aim to capture the complexity of transitions, considering the dynamics between niches, regimes, and landscapes. They help explain the processes of system innovation, path dependency, and change. While early studies concentrated on niche innovations, newer research has increasingly explored the role of incumbent regimes and the interactions between emerging and established technologies in shaping sustainable transitions.

2. Examining power and politics in transitions. Transitions are inherently political, as various actors and groups contest the direction and speed of change. This agenda explores the power dynamics that influence sustainability transitions, particularly the resistance of incumbent industries and the lobbying efforts of emerging actors. The research draws from policy science theories such as advocacy coalitions and discourse coalitions to study how power shapes transition outcomes. Attention is given to the politics of governance, where power struggles between regime actors and innovators determine the pace and scope of transitions toward sustainability, with implications for equity and justice.

3. Governing transitions — approaches and frameworks agenda examines the governance of sustainability transitions, highlighting the role of multiple actors, from governments to civil society, in shaping the path forward. Transition management (TM) and strategic niche management (SNM) offer frameworks for guiding transitions, promoting collaboration across sectors. It emphasises the importance of governance mechanisms that can deal with the uncertainties and complexities of transitions. Recent developments in governance focus on the role of transition arenas, policy mixes, and the experimental approaches needed to address sustainability challenges at local, national, and international levels.

4. Integrating civil society, culture, and movements in transitions agenda recognises the critical role of civil society and social movements in driving sustainability transitions. These groups influence

industrial change by advocating for policies, providing protective spaces for innovation, and challenging existing cultural values. Research in this field examines crowdsourced innovation assessment and management, the role of social movements in shaping public policies, and the cultural shifts necessary to support sustainability. Civil society's efforts often lead to societal transformations, influencing consumer preferences, policy frameworks, and broader cultural norms, thereby promoting a transition towards more sustainable practices.

5. Engaging organisations and industries in transitions agenda investigates the role of firms and industries in sustainability transitions, focusing on how businesses drive innovation, market formation, and the reorientation of industries towards more sustainable practices. Industries not only develop new technologies and services but also influence policy and public opinion through lobbying, discourse, and framing. This research highlights the tensions between incumbents, who may resist change, and new entrants, who drive radical innovations. Understanding how businesses interact with institutional changes, create legitimacy for new technologies, and contribute to the emergence of new industries is vital for effective transition strategies.

6. Exploring transitions in practice and everyday life agenda explores how sustainability transitions unfold in everyday practices, including consumption and lifestyle changes. It examines the role of users in innovation and transition processes, focusing on how individuals and communities adopt, adapt, and advocate for sustainable technologies. Practice theory is applied to understand the persistence of resource-intensive behaviours and the potential for transformative shifts in daily life. Research in this area investigates the social dynamics of consumption, user involvement in innovation, and the impact of everyday practices on broader sustainability transitions from the household level to society at large.

7. Understanding the geography of transitions — spaces and scales. The geography of transitions examines how sustainability transitions vary across different regions and scales. It highlights the role of local institutions, natural resources, and regional networks in shaping transitions, as well as the transfer of innovations between places. Research in this area explores how different geographical contexts—rural, urban, or global—facilitate or hinder the development and diffusion of sustainable practices. It also considers how global networks and local experiments interact, with particular attention to urban transitions

and the role of cities in driving sustainability through experimentation and innovation.

8. Ethical considerations in transitions — justice and equity agenda focuses on the ethical dimensions of sustainability transitions, addressing concerns of justice, distribution, and poverty. It explores how transitions can perpetuate or alleviate inequalities, considering the impacts of technological and social innovations on vulnerable communities. Research highlights the importance of ensuring that transitions are just, inclusive, and equitable, ensuring that marginalised groups benefit from sustainable development. It also examines the ethical implications of policy decisions, including the distribution of costs and benefits, and calls for a more explicit integration of justice considerations into sustainability transition frameworks.

9. Reflecting on methodologies for transitions research agenda reflects on the methodologies used in sustainability transitions research, emphasising the need for methodological pluralism. It addresses key dilemmas such as balancing in-depth case studies with the search for broader, generic insights, and reconciling micro-level investigations with macro-level frameworks. The agenda also considers the complexity of transitions, arguing for approaches that can capture the non-linear dynamics of system change. Methodological advancements include the integration of qualitative and quantitative methods, the use of comparative case studies, and the exploration of transdisciplinary approaches that engage with policy and real-world experiments to catalyse transitions.

3.1.3. EUROPEAN GREEN DEAL AGENDAS

The ten European Green Deal (EGD) agendas outline a comprehensive framework for achieving climate neutrality and sustainability across the EU. In addition to the original eight priorities, two more agendas have been added to reflect the European Commission's increasing emphasis on sustainable finance and the internationalisation of climate diplomacy, positioning the EU as a global leader in climate action. These agendas highlight the EU's role in fostering clean energy transitions, reducing pollution, preserving ecosystems, and promoting sustainable mobility and food systems.

1. Becoming climate-neutral by 2050 for Europe. The European Green Deal (EGD) sets the ambitious target of achieving a net-zero carbon European Union by 2050, with interim goals including

a 55% reduction in greenhouse gas emissions by 2030. This transformation demands an overhaul of policies, including new legislation to strengthen climate targets across various sectors. Achieving climate neutrality requires broad participation from all societal actors, including businesses, governments, and individuals, ensuring a comprehensive transformation that spans the economy and everyday life for all EU citizens.

2. Driving a clean and efficient energy transition. The Green Deal prioritises the transition to renewable energy sources, such as wind and solar, to reduce the EU's dependence on fossil fuels. Aiming for affordable, clean, and secure energy for all EU citizens, this agenda addresses energy poverty while promoting energy efficiency across member states. Since energy production accounts for over 75% of the EU's greenhouse gas emissions, decarbonising the energy system is crucial to meet the EU's 2030 climate objectives and the long-term goal of carbon neutrality by 2050.

3. Mobilising industry for a clean circular economy. The Green Deal promotes a circular economy model that decouples economic growth from resource consumption. By mobilising industries and integrating green technologies, it aims to foster sustainable, job-creating economic models that align with environmental objectives. Transitioning to a circular economy will reduce pressure on natural resources, halt biodiversity loss, and stimulate sustainable growth. Local governments and small businesses have significant roles in scaling these models, benefiting both citizens and the local economies, thus contributing to the EU's 2050 climate neutrality goal.

4. Building energy- and resource-efficient structures. Improving energy performance in buildings is a key focus of the European Green Deal, aiming to reduce energy consumption and emissions. Renovating existing buildings and constructing new, energy-efficient structures is vital for meeting climate targets. With buildings accounting for approximately 40% of Europe's energy use, the need for energy-efficient solutions is critical. The Renovation Wave Strategy, launched in 2020, addresses this challenge, particularly in retrofitting 85% of European buildings built before 2001, engaging citizens in the transformation to improve sustainability across Europe's housing stock.

5. Reducing pollution for a toxic-free environment. The European Green Deal aims to cut pollution across air, water, and soil, ensuring a toxic-free environment for all. It focuses on strengthening industrial

pollution controls and enhancing regulations to reduce harmful emissions. Pollution remains a significant environmental and health issue, with detrimental effects on public health, especially for vulnerable populations. The EU's Zero Pollution Action Plan seeks to address air quality, plastic waste, chemical pesticide use, and more in collaboration with citizens to create a cleaner, healthier, and more sustainable European environment.

6. Preserving ecosystems and restoring biodiversity. The Green Deal underscores the need to protect biodiversity and reverse the loss of ecosystems. The EU's Biodiversity Strategy for 2030 aims to safeguard natural habitats, conserve species, and restore damaged ecosystems, including through the creation of protected areas. Biodiversity plays a fundamental role in food production, health, and climate regulation. With the goal of protecting 30% of European land, restoring ecosystems on land and at sea is essential for ensuring sustainable growth and enhancing public awareness of the importance of biodiversity preservation.

7. Transforming food systems for sustainability. The Farm to Fork Strategy focuses on creating a sustainable, healthy, and fair food system across Europe. This agenda promotes sustainable farming practices, reduces food waste, and aims to enhance food security. The food sector, which accounts for about one-third of global greenhouse gas emissions, must evolve to meet both environmental and public health goals. The EU's strategy addresses these challenges, using new technologies, scientific discoveries, and increased public demand for sustainable food to create a food system that benefits all stakeholders, from producers to consumers.

8. Accelerating the shift to sustainable mobility. A central objective of the European Green Deal is to reduce emissions from transport, a significant contributor to EU greenhouse gas emissions. This agenda focuses on promoting electric vehicles, alternative fuels, and sustainable public transport systems to create a more connected, low-carbon mobility system. Urban mobility is specifically targeted through the European Urban Mobility Framework, which proposes measures for cities to develop more sustainable transport solutions. Achieving climate neutrality by 2050 requires reducing transportation emissions and enhancing the sustainability of urban transport networks across Europe.

9. Leveraging sustainable finance for green goals. Sustainable finance is essential for supporting the Green Deal's goals, ensuring that investments

align with climate and environmental objectives. The EU aims to mobilise substantial funds through initiatives such as InvestEU, with at least 25% of the EU budget dedicated to climate change mitigation. This agenda includes incorporating environmental, social, and governance (ESG) considerations into financial decisions, promoting long-term investments in sustainable economic activities. By addressing climate change, pollution, and social inequalities, sustainable finance aims to support the EU's transition to a greener, more inclusive economy with transparent risk management strategies.

10. Leading global climate action and diplomacy efforts. The European Green Deal positions the EU as a global leader in climate action, promoting international cooperation and climate diplomacy to address global sustainability challenges. By strengthening partnerships with neighbouring regions like Africa and the Mediterranean, the EU aims to foster green investments and lead multilateral climate negotiations. The EU's external strategy involves a blend of collaborative, coercive, and diplomatic approaches, ensuring that the global green transition is inclusive, just, and aligned with Europe's climate-neutral objectives by 2050, encouraging widespread international commitments to climate resilience.

3.1.4. COMPARATIVE ANALYSIS: QUADRUPLE HELIX STAKEHOLDER ROLES IN SUSTAINABILITY AGENDAS

The comparative matrix presented below assesses the role and intensity of the four key stakeholders - government, business, academia, and civil society — across the ten CASI SI agendas, nine sustainability transition agendas, and ten European Green Deal agendas. The purpose of this analysis is to capture the extent of each stakeholder's involvement in advancing the respective agendas, focusing on their unique contributions to sustainable innovation, transitions, and policy formulation.

The quadruple helix model, which encompasses government, business, academia, and civil society, is used to evaluate the level of engagement of each stakeholder group in the implementation and impact of the sustainability agendas. This approach acknowledges that sustainable transitions require the active participation of multiple actors who can offer diverse perspectives and expertise. Governments are typically responsible for policymaking, regulatory frameworks, and the establishment of incentives; businesses drive innovation and market solutions; academia

Tab. 1. Quadruple helix stakeholder comparative matrix

AGENDA	GOVERNMENT	BUSINESS	ACADEMIA	CIVIL SOCIETY
SIA 1. Tackling climate change and reducing greenhouse gas emissions	High. Governments set policies, regulations, and frameworks for climate action.	Medium. Businesses implement low-carbon practices, adopting green tech.	High. Academia drives research and innovation in climate solutions.	High. Civil society advocates, mobilises, and ensures public support.
SIA 2. Enhancing governance through foresight and data-driven intelligence	High. Governments drive foresight planning and policymaking.	Medium. Businesses provide data and contribute to technological solutions.	High. Academia conducts research to refine foresight methodologies.	Low. Limited role in foresight processes, mainly a receiver of policy.
SIA 3. Building integrated sustainable infrastructures for a circular bioeconomy	High. Governments provide regulatory frameworks and financial incentives.	High. Businesses innovate, provide technology, and scale sustainable practices.	High. Academia leads research on circular economy models and best practices.	Medium. Civil society participates in local solutions, demanding sustainability.
SIA 4. Advancing responsible environmental management and resource efficiency	High. Governments create policies for resource management and regulation.	High. Businesses apply resource-efficient practices and innovate for sustainability.	Medium. Academia develops tools and technologies but has limited practical reach.	High. Civil society influences and demands sustainable resource management.
SIA 5. Accelerating the transition to renewable energy and biofuels	High. Governments set policies, regulations, and financial mechanisms for energy transition.	High. Businesses lead renewable energy production, biofuel innovation, and distribution.	High. Academia conducts research and provides technological breakthroughs.	Medium. Civil society supports transitions and advocates for energy equity.
SIA 6. Innovating sustainable transport and mobility systems	High. Governments create transport policies, subsidies, and infrastructure.	High. Businesses develop and commercialise electric vehicles and sustainable transport solutions.	Medium. Academia provides innovative solutions and evaluates sustainable transport impacts.	Medium. Civil society participates in public campaigns and adopts new mobility solutions.
SIA 7. Advancing circular economy and waste resource management	High. Governments regulate waste management and incentivise circular practices.	High. Businesses innovate circular supply chains and recycling processes.	High. Academia conducts research on efficient waste management systems.	High. Civil society demands improved waste management and engages in recycling.
SIA 8. Enhancing eco-community resilience and collaborative development	High. Governments create policies and support initiatives for community resilience.	Medium. Businesses support sustainable development projects and local economies.	Medium. Academia explores and evaluates resilience models for communities.	High. Civil society organises grassroots movements and empowers local communities.
SIA 9. Embedding sustainability in education and skills development	High. Governments promote policies and curricula for sustainability education.	Low. Businesses offer some training but have limited influence on education.	High. Academia is central to integrating sustainability into education systems.	Medium. Civil society engages in educational campaigns and promotes learning.
SIA 10. Promoting sustainable agriculture and localised food systems	High. Governments provide subsidies, policy support, and frameworks for sustainable agriculture.	High. Businesses innovate in sustainable farming technologies and local food systems.	High. Academia leads research on sustainable farming practices and food systems.	High. Civil society supports local agriculture and campaigns for food system transformation.
STA 1. Understanding transitions — theoretical frameworks and insights	Medium. Governments implement transition strategies based on theoretical insights.	Medium. Businesses adapt models from theoretical frameworks for innovation.	High. Academia develops and refines theoretical frameworks for sustainability transitions.	Low. Limited role, primarily as beneficiaries of academic research outputs.
STA 2. Examining power and politics in transitions	High. Governments play key roles in managing power dynamics through policy.	Medium. Businesses influence transitions through lobbying and political power.	Medium. Academia explores power dynamics and contributes research on sustainability transitions.	High. Civil society advocates for just transitions and political accountability.
STA 3. Governing transitions — approaches and frameworks	High. Governments govern and coordinate transitions at various levels.	Medium. Businesses adapt to governance changes, integrating sustainable practices.	High. Academia contributes to governance models and framework development.	Medium. Civil society engages in the consultation processes for governance models.

STA 4. Integrating civil society, culture, and movements in transitions	Medium. Governments collaborate with civil society to implement cultural shifts.	Low. Businesses may support but have minimal involvement in cultural and social movements.	Medium. Academia studies and supports the integration of culture into sustainability transitions.	High. Civil society drives cultural shifts, policy advocacy, and community mobilisation.
STA 5. Engaging organisations and industries in transitions	High. Governments provide incentives and policies for business involvement.	High. Businesses are central to innovation, industrial shifts, and market-driven transitions.	Medium. Academia provides research but is more of a supporting player in this agenda.	Low. Civil society has a limited direct role in business and organisational transitions.
STA 6. Exploring transitions in practice and everyday life	Medium. Governments create enabling policies for sustainable practices at the individual level.	Medium. Businesses influence consumer behaviour and support everyday sustainability solutions.	High. Academia studies practices and provides insights on sustainable living.	High. Civil society is central to implementing everyday sustainability through grassroots actions.
STA 7. Understanding the geography of transitions — spaces and scales	High. Governments define spatial policies and regional planning for transitions.	Medium. Businesses adapt to different regional contexts and manage localised supply chains.	Medium. Academia investigates regional transitions and how spatial scales impact sustainability.	Medium. Civil society plays a role in implementing local initiatives but is less influential at higher scales.
STA 8. Ethical considerations in transitions — justice and equity	High. Governments define policies to ensure equity and fairness in transitions.	Medium. Businesses must align with ethical standards and address equity in operations.	Medium. Academia contributes research on the ethics of transitions and equity considerations.	High. Civil society ensures that ethical concerns and justice are central to sustainability.
STA 9. Reflecting on methodologies for transitions research	Low. Limited government involvement in the development of research methodologies.	Low. Business involvement is minimal; primarily academic-driven methodologies.	High. Academia leads methodological innovations for studying transitions.	Low. Civil society is primarily a beneficiary of the methodologies developed.
EGD 1. Becoming climate-neutral by 2050 for Europe	High. Governments set ambitious targets, policies, and regulatory frameworks.	Medium. Businesses implement solutions but are heavily influenced by government policies.	Medium. Academia supports policy development and technological innovations.	Low. Civil society's role is largely as supporters, less directly involved in policy creation.
EGD 2. Driving a clean and efficient energy transition	High. Governments set energy transition goals and implement regulations and incentives.	High. Businesses provide renewable energy solutions, technologies, and infrastructure.	Medium. Academia provides energy-related research and evaluates transition impacts.	Medium. Civil society supports the transition and advocates for energy access equity.
EGD 3. Mobilising industry for clean circular economy	High. Governments create frameworks for industry participation and regulation.	High. Businesses are key players in developing and scaling circular economy models.	High. Academia supports research on best practices and business models for circularity.	Medium. Civil society supports through advocacy for reduced waste and increased recycling.
EGD 4. Building energy- and resource-efficient structures	High. Governments set building codes and policies for energy-efficient structures.	High. Businesses innovate in construction and energy-efficient technologies.	Medium. Academia contributes through research on energy-efficient materials and systems.	Low. Civil society's role is limited to adopting energy-efficient practices in buildings.
EGD 5. Reducing pollution for a toxic-free environment	High. Governments regulate pollution, set limits, and enforce compliance.	Medium. Businesses are affected by regulations but also innovate in pollution reduction.	Medium. Academia studies pollution reduction technologies and their effectiveness.	High. Civil society advocates for pollution reduction and public health safety.
EGD 6. Preserving ecosystems and restoring biodiversity	High. Governments create policies, protected areas, and biodiversity strategies.	Medium. Businesses help through sustainability practices and biodiversity-friendly innovations.	High. Academia conducts research and provides strategies for ecosystem restoration.	High. Civil society plays a key role in advocacy, conservation efforts, and education.
EGD 7. Transforming food systems for sustainability	High. Governments regulate food systems and set policies for sustainability.	High. Businesses play a major role in transitioning the food sector towards sustainability.	Medium. Academia contributes research on sustainable farming and food systems.	High. Civil society pushes for food security, health, and sustainable agriculture.
EGD 8. Accelerating the shift to sustainable mobility	High. Governments create policies and infrastructure for green mobility solutions.	High. Businesses provide electric vehicles, sustainable transport technologies, and services.	Medium. Academia researches transportation systems and sustainable mobility.	Medium. Civil society advocates for equitable mobility and the adoption of clean technologies.

EGD 9. Leveraging sustainable finance for green goals	High. Governments regulate green investments and provide financial mechanisms.	High. Businesses attract investments and drive green economic growth.	Medium. Academia contributes research on sustainable finance models and investment strategies.	Low. Civil society's role is more indirect, advocating for ethical investments.
EGD 10. Leading global climate action and diplomacy efforts	High. Governments take the lead in international negotiations and commitments.	Medium. Businesses align with international climate policies but may resist strict measures.	Low. Academia supports through research but plays a secondary role in diplomacy.	Low. Civil society plays a minimal role in international climate diplomacy efforts.

provides research, analysis, and new technological developments; and civil society plays a crucial role in advocacy, public mobilisation, and ensuring accountability.

The comparative analysis highlights several key patterns. First, it is evident that governments have a high level of involvement in nearly all the agendas, as they set regulatory frameworks and policies and provide financial incentives. Business stakeholders, often second in influence, are central to scaling innovations, particularly in areas like renewable energy, circular economies, and sustainable agriculture. Academia's role, although significant, is mostly focused on research, technological advancements, and theoretical frameworks, which provide essential guidance for policy and business practices. Civil society, while influential in many areas, particularly in advocating for sustainability and raising awareness, often has a secondary role in the formal implementation of policy agendas.

The matrix further reveals that certain agendas require more collaborative involvement, such as those related to community resilience, circular economy, and sustainable mobility, where the active participation of all four stakeholders is essential for achieving long-term sustainability. For example, the "Advancing circular economy and waste resource management" agenda requires high involvement from both government and business for regulation and innovation, while academia and civil society contribute through research and public advocacy. Conversely, agendas like "Enhancing governance through foresight and data-driven intelligence" see a more prominent role for governments and academia, with limited direct involvement from business and civil society.

In conclusion, the comparative matrix offers valuable insights into the varying degrees of stakeholder involvement in each agenda, highlighting both synergies and potential gaps. It underlines the importance of fostering greater collaboration across these stakeholder groups, particularly in areas where grassroots-driven innovation and top-down policy frameworks

intersect. The analysis sets the stage for further exploration into how these stakeholders can work more effectively together to advance the goals of the European Green Deal and other sustainability agendas.

3.2. KEY FEATURES OF EACH AGENDA

While there are notable alignments between the CASI SI agendas, the transitions research agendas, and the European Green Deal agendas, several gaps and differences have been identified across their focus areas. These gaps highlight opportunities for further integration and refinement of the Green Deal's approach. By addressing these discrepancies, the Green Deal could benefit from a more holistic and inclusive strategy, ensuring a more participatory and comprehensive transition towards sustainability. This would not only strengthen the Green Deal's objectives but also enhance its alignment with both crowd-sourced innovation management and the broader societal shifts necessary for a sustainable future.

- Sustainable innovation agendas (Popper et al., 2017a, 2017b, 2017c). The SI agendas are distinguished by their strong focus on quadruple helix and ecosystem-oriented innovation approaches, fostering collaboration across diverse sectors. They prioritise the importance of localised efforts, such as fostering eco-community empathy, crowd-funded development, and eco-local agriculture. The SI agendas focus on practical, bottom-up innovations that involve local communities and small-scale initiatives, thereby addressing sustainability from a more regional and community-specific perspective. This approach complements the more top-down, policy-driven frameworks seen in other agendas. Additionally, SI agendas place a high value on the integration of sustainability across sectors such as bioeconomy and urban infrastructures and promoting sustainability in cultural and educational contexts.

- Sustainable transition agendas (Köhler et al., 2019). Transition research agendas are distinct for their academic focus on the dynamics of sustainability transitions, especially the social, political, and cultural dimensions. These agendas investigate the role of power, governance, and social movements in facilitating or hindering transitions. They also explore ethical considerations in transitions, such as justice, equity, and poverty. This framework places a strong emphasis on understanding transitions as complex, multi-dimensional processes, with a focus on both theoretical and methodological advancements in transition research.
- European Green Deal agendas (EC, 2019a, 2019b, 2020). The European Green Deal agendas are unique in their overarching focus on achieving Europe's climate-neutral goals by 2050, positioning Europe as a global leader in sustainability transitions. These agendas strongly emphasise the transformation of the European economy, particularly in energy, transport, and agriculture. The Green Deal underscores the importance of achieving decarbonisation and resource efficiency at a large scale, with goals like circular economies, sustainable mobility, and clean energy. Moreover, the Green Deal highlights inclusivity and social justice in the transition, ensuring that no region or community is left behind in the shift towards sustainability.

3.3. TOWARDS A HARMONISED AGENDA

CASI-F, in conjunction with CASIPEDIA, can make a substantial contribution towards harmonising the diverse sustainability agendas outlined here by serving as a central platform that integrates bottom-up innovations with top-down policy objectives. CASI-F's emphasis on community-driven projects and local innovations complements the European Green Deal's broader sustainability goals, fostering synergies between local and European initiatives. "When a technology is consumed as part of a system, the performance that matters to the consumers' assessment of value is not the performance of the focal technology on its own, but is rather a function of its interaction with the other elements of the system" (Adner & Kapoor, 2016). This highlights that the impact of local innovations, when integrated into broader systems, can be more pronounced than when considered in isolation. By systematically mapping and evaluating sustainable innovations through

CASIPEDIA-like tools, these projects can be linked to wider global and European sustainability objectives, thereby facilitating better alignment with the SDGs.

Moreover, the application of foresight and anticipatory intelligence within CASI-F's governance framework can aid in assessing future challenges and opportunities, thereby offering a proactive approach to sustainability management. "The relative pace at which the new technology will substitute the old technology will depend on the joint levels of ecosystem emergence challenge for the new technology and the ecosystem extension opportunity for the old technology: fastest when both are low, slowest when both are high, and intermediate in the mixed case where one is high and one is low" (ibid.). This underscores the importance of creating optimal conditions for the co-evolution of technologies within a system, which is critical for accelerating transitions (Aarikka-Stenroos & Ritala, 2017). By collecting comprehensive data on regional innovations and practices, CASIPEDIA can provide invaluable insights into the effectiveness of these innovations, thereby contributing to ongoing policy development and guiding future research directions in sustainability transitions. Consequently, CASI-F and CASIPEDIA have the potential to serve as an effective bridge, uniting research, policy, and practice in a cohesive and integrated manner, thus fostering a more harmonised and dynamic sustainability agenda across Europe and beyond.

CONCLUSION

Innovation ecosystems play a crucial role in advancing the objectives of the European Green Deal by offering pathways for systemic transformation that align technological innovation with broader social, economic, and institutional changes. These ecosystems facilitate multi-level collaboration, effectively integrating DIY and crowdsourced innovation management with top-down policies, which can accelerate Europe's transition to a climate-neutral and resource-efficient economy. The lessons derived from the CASI project and its sister BOLERO project provide valuable insights for refining the Green Deal's framework, ensuring that it remains not only ambitious but also inclusive and resilient in addressing the complex sustainability challenges we face today and in the future.

One core principle emerging from this study is the importance of adopting a global perspective while

acting locally. Although the European Green Deal presents a high-level vision for a climate-neutral Europe, it is at the local level where the most impactful changes often take place. DIY and crowdsourced initiatives – such as community-led energy cooperatives, decentralised agriculture, and locally driven circular economy projects – hold significant potential to drive meaningful change. These bottom-up solutions can be scaled up and integrated into national and regional frameworks, ultimately contributing to global sustainability objectives. By empowering local communities and fostering innovation, the Green Deal has the capacity to create a more inclusive, resilient, and adaptive transition.

The integration of local innovations into broader national and regional policies is essential for developing a flexible, responsive approach that addresses sector-specific and regional needs while still aligning with global sustainability goals. This integration promotes greater coherence between policy levels, enhancing the ability to address diverse challenges and ensuring that no region or community is left behind. Strengthening policy coherence across local, national, and EU levels is not only critical for the success of the Green Deal but also vital for driving a transition that is sustainable, equitable, and adaptable to future challenges. “The co-evolutionary logic shifts the focus from the evolution and exchange of a business network to system co-evolution... Ecosystems cross industry boundaries, connecting various types of business and innovation networks in an exchange that is embedded in an institutional and socio-technical environment” (ibid). A relevant example of this co-evolution is seen in the interaction between the CASIPEDIA and BOLERO platforms. These platforms act as bridges between European-level and regional innovation ecosystems focused on sustainability. By connecting local sustainability innovations in the BOLERO platform with the broader policy and research initiatives showcased in CASIPEDIA, they facilitate a dynamic exchange of knowledge, technologies, and best practices that fosters system-wide sustainability transitions.

Thus, this study reinforces the need for a more harmonised, multi-actor approach – blending DIY and crowdsourced innovation management, policy agendas, and cross-sectoral collaboration – ensuring that Europe can move forward as a global leader in sustainability and climate resilience.

Recommendations for policy enhancements: This section outlines key recommendations for enhancing the European Green Deal’s effectiveness

and inclusivity, with the goal of ensuring a transformative and sustainable transition to a climate-neutral future. The recommendations emphasise the integration of local, community-driven initiatives into broader policy frameworks, fostering an approach that is both adaptable and equitable. Key strategies include strengthening community engagement, advancing sustainability education, scaling DIY and crowdsourced innovation management, improving innovation mapping tools, and incorporating SMART foresight processes. By implementing these measures, Europe can create a more resilient, inclusive, and forward-looking sustainability strategy, empowering local communities while reinforcing global sustainability objectives.

1. Strengthening community engagement. To ensure that the Green Deal is inclusive and equitable, it is essential to develop and expand participatory mechanisms that actively engage local communities in the design and implementation of sustainability policies. Local communities possess invaluable knowledge and insights, which can help shape policies that are both effective and contextually relevant. By involving these communities in decision-making processes, policies will reflect diverse needs and foster greater ownership and accountability in the green transition. As Geels and Schot (2007) point out, “ecosystems cross industry boundaries, connecting various types of business and innovation networks in an exchange that is embedded in an institutional and socio-technical environment”, which suggests that integrating local knowledge into larger systems can provide mutually beneficial outcomes, aligning community-driven innovations with broader policy frameworks.

2. Advancing sustainable innovation mapping. To optimise the European Green Deal’s impact, it is crucial to further advance tools like CASIPEDIA and BOLERO, which systematically support the mapping and assessment of sustainable innovations across Europe. These platforms play a pivotal role in identifying, sharing, and scaling locally-driven initiatives, fostering collaboration and knowledge exchange. By combining qualitative and quantitative approaches, it would be possible to develop a more universal or hybrid framework for sustainable innovation (SI), which could help reduce fragmentation and divisions within the growing community of SI practitioners and scholars (Pajula & Popper, 2020). Expanding and enhancing these tools would strengthen the integration of DIY and crowdsourced innovation management into broader policy frameworks, ensuring that

Europe's sustainability efforts are both informed and inclusive. This hybrid approach, which bridges the boundaries across sectors and regions, can facilitate the alignment of local innovations with EU-wide policies. The integration of local innovations into national and regional policies is vital for developing a flexible, responsive approach that addresses sector-specific and regional needs while still contributing to global sustainability goals. The systematic assessment and management of SI provides unique and shared benefits to multiple stakeholders, making it accessible across different areas of science and industry and capable of delivering the results needed to address and meet current challenges. This underscores the importance of adapting local solutions to larger frameworks like the European Green Deal, ensuring that bottom-up, DIY-driven initiatives align with top-down policy objectives and contribute to a more cohesive, comprehensive transition.

3. Promoting sustainability education across Europe. Integrating sustainability education into all levels of the European education system — from primary schools to higher education — is essential for the long-term success of the Green Deal. By embedding eco-literacy and sustainability-focused curricula, Europe can equip future generations with the skills and knowledge required to actively contribute to a more sustainable future. This educational approach must also emphasise the ethical dimensions of sustainability, enabling citizens to understand the social, environmental, and economic implications of their actions. Education for sustainability should aim to foster a critical understanding of technology and social organisation, encouraging learners to reflect on how both can promote harmony between people and the natural world. As Huckle (1991) pointed out in one of the earliest works on this subject, such education must empower students to engage in democratic processes that can drive societal transformation. The development of new knowledge and values is crucial for building a broad-based support system for sustainability innovations, especially in the context of the co-evolution of niche innovations with societal values. Higher education institutions play a central role in preparing future leaders who will help achieve the United Nations Sustainable Development Goals (Žalėnienė & Pereira, 2021).

4. Scaling and integrating DIY and crowdsourced innovation management. The European Green Deal would greatly benefit from increased support for scaling successful DIY and crowdsourced innovation management practices, including grass-

roots-level initiatives. Financial and technical support for community-driven projects — such as renewable energy cooperatives, urban farming, and circular economy ventures — will enable these local initiatives to contribute more effectively to national sustainability goals and create scalable models for broader implementation. By embedding these innovations into broader policy frameworks, Europe can ensure that sustainability strategies remain adaptable to diverse regional needs while reinforcing the global sustainability agenda. This approach can help foster resilient, adaptive systems that leverage local knowledge and resources for maximum impact. In line with Aarikka-Stenroos and Ritala's (2017) focus on value co-creation, facilitating the scaling of DIY and crowdsourced innovation management will foster collaborative relationships between multiple stakeholders, thus enhancing the overall value generated by these local projects and aligning them more closely with broader sustainability objectives. As noted by Callaghan (2016) and Popper et al. (2025), this approach is particularly valuable in crisis management, where geopolitical instability and unpredictable events, or "wild cards", are increasingly shaping every aspect of innovation ecosystems. These disruptions require more agile and responsive frameworks that can draw upon a diverse range of inputs from crowd-sourced R&D and social media platforms. By integrating real-time problem-solving and probabilistic innovation, Europe and other world regions can better navigate these complexities, enabling faster, more collaborative solutions to urgent global challenges.

5. Adopting SMART foresight for future-oriented policymaking. The adoption of SMART foresight processes (Popper, 2011, 2012) offers significant potential to enhance the effectiveness of the European Green Deal by providing a structured framework for future-oriented policymaking. This approach guides decision-making through distinct phases — scoping, mobilising, anticipating, recommending, and transforming — which together create a dynamic cycle of strategic foresight. Integrating this foresight methodology (Popper, 2008) into the Green Deal will enable the European Union to ensure its policies are both forward-looking and flexible, capable of responding proactively to emerging challenges and uncertainties. This approach provides a comprehensive roadmap for the sustainability transition, helping to identify potential risks, set clear priorities, and mobilise a diverse range of stakeholders to implement effective sustainability solutions. Through the creation of a "space" for discourse, analysis, and creative vision-

ing, foresight empowers policymakers to consider long-term implications and explore innovative pathways that might otherwise be overlooked (Miles et al., 2008; Velasco et al., 2021). Furthermore, by combining foresight with other strategic policy intelligence tools such as evaluation and technology assessment, the EU can ensure that the Green Deal is grounded in actionable, evidence-based strategies that meet current needs while being resilient to future disruptions. The integration of SMART foresight ensures that the Green Deal is adaptive, resilient, and capable of responding to evolving environmental, social, and technological contexts, ultimately fostering a more sustainable and inclusive future for Europe.

By implementing these recommendations, regions worldwide can accelerate their transitions to a climate-neutral future that is transformative, inclusive, adaptive, and resilient. Empowering citizens and communities to actively contribute to a sustainable future will be crucial for achieving long-term climate objectives. The integration of bottom-up innovations and local solutions into national, regional, and global frameworks will foster a sustainable, just transition that addresses the diverse needs of communities while reinforcing global sustainability goals.

Further research and a way forward: As the European Green Deal strives to meet its ambitious sustainability targets, future research should prioritise enhancing emerging frameworks that underpin sustainable innovation. Building on lessons from established tools such as CASI-F and BOLERO, integrating the complementary Candy Innovation Model, developed at La Salle – Ramon Llull University, offers a promising avenue for advancing both methodology and impact. With its structured approach spanning four key phases — challenges, ideas, development, and scalability — the model aligns closely with the principles of CASI-F and BOLERO, particularly in fostering multi-level stakeholder engagement and supporting scalable innovation solutions. As Pique et al. (2017) underscore, the model's emphasis on addressing real-world challenges through collaborative problem-solving provides invaluable insights for navigating complex sustainability issues, ensuring that local innovations are developed, tested, and scaled effectively in alignment with broader policy frameworks.

Originally developed to address regional innovation needs in Catalonia, Spain, the approach has since expanded to other Spanish regions and is being adopted across Latin America through universities within the La Salle network. This broad implementa-

tion demonstrates the model's adaptability across diverse geographical and cultural contexts. Future research should explore how this methodology can be integrated into national and EU-level policy frameworks to enhance sustainability efforts.

Additionally, research should address the scalability potential of sustainability projects within the EU context. Integrating this model into CASI-F presents an opportunity for enhanced cross-border collaboration, pooling expertise from industry, academia, government, and civil society. This integration ensures that local solutions to sustainability challenges are effective and adaptable across regions, aligning innovations with EU-wide sustainability targets. The model's emphasis on testing, prototyping, and real-time feedback from diverse stakeholders will help develop policies that are both forward-looking and resilient to global challenges. Through continued adaptation and refinement, Europe can establish a more integrated, adaptive, and inclusive framework for achieving sustainability, empowering local communities to contribute meaningfully to the broader transformation envisioned by the European Green Deal.

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