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Addressing sustainability challenges and Sustainable Development Goals via Smart Specialisation

Towards a theoretical and conceptual framework

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TABLE OF

Contents

Abstract 1
Acknowledgements 1
Executive summary 2
INTRODUCTION 4
1. RESEARCH FRAMEWORK FOR S3 FOR SDGS 6
1.1. Research problem 6
1.2. Research questions 6
1.3. Methodology 7
2. LITERATURE REVIEW 9
2.1. Origins, critique and evolution of the S3 concept 9
2.1.1. The concept of Smart Specialisation 9
2.1.2. Recent critique and evolution of the concept 10
2.1.3. Key challenges for aligning S3 with the SDGs 11
2.2. Theoretical and conceptual perspectives linking place-based innovation with sustainable development 15
2.2.1. Sociotechnical transitions 16
2.2.2. Social-ecological resilience 24
2.2.3. Sustainability-oriented innovation policy 32
2.3. Key insights into Smart Specialisation from the literature review 43
3. TOWARDS A FRAMEWORK OF SMART SPECIALISATION FOR THE SDGS 51
3.1. Guiding principles 51
3.2. Embedding the SDGs in the components of S3 52
4. CONCLUSIONS AND RECOMMENDATIONS 57
REFERENCES 60
Glossary 66
List of abbreviations 66
List of figures 67
List of tables 68

ANNEX I. TENTATIVE QUESTIONNAIRE FOR ONGOING SELF-EVALUATION AND REFLECTION ON EMBEDDING THE SDGS IN S3 70

The point of departure 70

Quick SDG scan 71

Self-assessment framework 71

Governance. Setting out the S3 process and governance to address the SDGs 71

Diagnosis. Localising sustainability challenges and analysing regional innovation potential to address the SDGs 71

Vision. Shared vision and scenarios of regional transition pathways towards the SDGs 72

Priorities. Embedding the SDGs in the S3 priority areas 72

Policy roadmap. How are you going to get there? 73

Monitoring, evaluation and policy learning for sustainability transitions 73

Steps to align S3 with the SDGs 74

ANNEX II. LITERATURE REVIEW PROTOCOL 75

ABSTRACT

Smart Specialisation for Sustainability builds on the Smart Specialisation concept of a place-based research and innovation agenda for regional economic transformation and extends this further to include the UN 2030 Agenda objectives (17 SDGs), the European Green Deal and aspects of social and environmental sustainability. The purpose of this study is to reflect upon the S3 framework within the context of transition studies, notably sociotechnical transitions, social-ecological resilience and challenge-driven innovation policy. The study includes a discussion on the strengths and limitations of the current S3 framework and makes suggestions on how to strengthen and revisit the S3 approach based on the insights from these approaches. The study proposes the guidelines, accompanied with a self-assessment tool for regions, in support of their effort in designing and implementing Smart Specialisation strategies for sustainable transformation.

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EXECUTIVE SUMMARY

There is a widely shared expectation that Smart Specialisation Strategies (S3) carry substantial potential to effectuate regional and national pathways to Sustainable Development Goals (SDGs) as part of the European Green Deal (EGD). This expectation is based on growing evidence from many European and non-EU regions and countries where S3 has been used to support innovation for green and inclusive growth. Based on this experience, the JRC has recently started promoting the use of S3 as a strategic approach helping to address the Sustainable Development Goals (SDGs).

The paper contributes to the discussion about how to better align the conceptual and methodological framework of Smart Specialisation with sustainability objectives, notably the SDGs. Our analysis juxtaposes the S3 framework with theoretical and conceptual approaches underpinning studies on transitions towards sustainability, notably sociotechnical transitions, social-ecological resilience and challenge-driven innovation policy. We reflect on the strengths and limitations of the current S3 framework and make suggestions on how to strengthen and revisit the S3 approach based on the insights from these approaches.

The main message from the review is that the S3 framework and methodology need to be revisited and extended if S3 is to facilitate innovation and systemic change in line with the SDGs. The reviewed studies offer a number of conceptual, methodological and practical insights, which could contribute to such an extension.

Firstly, to align with the SDGs, S3 should explicitly embrace and embed sustainability goals at the heart of its conceptual and methodological framework. The S3 framework needs to broaden its overall strategic orientation from supporting economic growth and competitiveness towards promoting sustainable development. This shift would align S3 with the EGD, which explicitly recognises the urgency and necessity of working towards the SDGs. One of the key functions of a renewed S3 framework would be to support regions and territories in identifying sustainability challenges most relevant to them and in situating the high-level global sustainability goals in their specific local contexts.

Secondly, a renewed S3 framework needs to extend its focus from supporting predominantly technological innovation towards a variety of innovations driving wider economic, environmental and social transitions needed to achieve the SDGs. The S3 framework has been applied by many regions and countries to promote sustainable growth by supporting the development of innovative green products and technologies. The framework, however, has not been designed to promote innovations leading to the transformation of entire systems, such as food, energy or mobility systems, needed to tackle sustainability challenges such as climate change or social exclusion. A revised S3 framework could act as a testbed for system innovation and governance experiments to develop, demonstrate and scale SDG-aligned mission-oriented approaches at regional and trans-regional level.

Thirdly, the S3 framework and methodology could benefit from expanding its theoretical and conceptual foundations to address complex, interconnected and uncertain societal challenges. Sustainability goals create new expectations and needs in terms of innovation, stakeholder engagement and governance arrangements as well as data and evidence used in monitoring and evaluation. This theoretical openness comes with challenges and risks as there are many differences and ambiguities between respective perspectives; theoretical integration itself requires an interdisciplinary debate with scholars and practitioners with different backgrounds. This report is but a modest contribution to what needs to be a more extensive, reflexive endeavour.

In practice, a revised S3 framework will need to be open to a great variety of pathways towards sustainability. The new framework must recognise that different countries and regions are in different phases on their journeys towards sustainability. The approach needs to be context-sensitive and consider the regions' different challenges, capacities and assets.

The variety of place-based pathways and emphasis on bottom-up experimentation should, however, go hand in hand with a strong directionality towards sustainability guiding S3 across all governance levels. Regardless of the context, S3 should have a common direction for all. To put it simply, regions should be pursuing a common set of overarching goals even if they will be moving at a different pace and using different pathways.

A new framework should encourage all regions to re-engage in the vision-building process, this time with a focus on sustainability challenges and localising the SDGs. This will allow regions to reflect on their current trajectory and on what they can do to change or accelerate the transition. Broadening the scope of S3 to embrace a greater variety of innovations and local actors will add new perspectives to the visioning process and inject new ideas on how to address local challenges.

It is key to emphasise that system innovation and sustainability transitions are not concepts for advanced regions only. The renewed S3 framework should support all types of regions. As in previous years, the new framework will need to be supported by policy platforms and interregional 'communities of practice' where the new approaches can be discussed, practical experiences shared and new collaborations forged.

The proposed extensions embedding the SDGs and the questionnaire for self-evaluation and reflection are prototypes which need further elaboration and co-creation with practitioners and experts. As mentioned above, the tools and guidance for the regions need to be further elaborated to be usable by regions with different interests and commitments to the SDGs. Feedback loops between policy development and implementation will need to be drastically shortened in order to meet the sustainability imperatives in this 'decade that matters' ahead of us.

Introduction

As of 2021, the European Union (EU) has entered a new multiannual programming period that will last until 2027. Within this framework, the European Commission designed and launched new strategies for sustainable, resilient, just and inclusive growth.

The new programming period strengthens the EU's commitment to delivering on the global Agenda 2030 and its Sustainable Development Goals. This affects all EU policies, including the European Green Deal (EGD) – a new EU sustainable growth agenda. In fact, the EGD contains a number of objectives and targets to achieve sustainable development, resilience and climate neutrality, among them:

- making the EU climate neutral by 2050;
- protecting life on the planet;
- helping companies become global leaders in clean products and technologies; and
- helping to ensure just and inclusive societies.

In terms of EU Cohesion Policy and the new Recovery and Resilience Facility, Smart Specialisation Strategies (S3) continue to play an extremely important role in EU countries and regions. S3 was originally adopted in 2013 under the European Structural and Investment Funds (ESIF) framework for the programming period 2014-2020. It was linked to Thematic Objective 1 – strengthening research, technological development and innovation – and put emphasis on the bottom-up prioritisation process, Entrepreneurial Discovery Process, measures to stimulate private R&D investments and monitoring. Smart Specialisation will be continued in the programming period 2021-2027 under the policy objective of a smarter Europe by promoting innovative and smart economic transformation. In addition, new fulfilment criteria have been introduced to ensure continuity and impact, such as actions to manage industrial transition and measures for international collaboration. This is increasingly considered as a territorial expression of national Recovery and Resilience Plans.

These connections are now further explored to deliver new guidance incorporating the findings of transformative innovation policy, sustainability and industrial transitions and other approaches.

At the same time, the European experience of Smart Specialisation has been increasingly recognised worldwide as a suitable STI-driven approach for the achievement of transformative economic change, with a particular emphasis on territorial and local needs. In recent years, there has been a growing interest in adopting Smart Specialisation as a reference approach to localised innovation-led transformation in a number of countries across the globe: 23 non-EU countries have been working on Smart Specialisation (e.g. Mexico or Australia), of which 13 are EU Enlargement and Neighbourhood countries and economies, including Ukraine, Montenegro, Serbia and Tunisia.

There is an expectation that S3 should foster the transition towards sustainability and make a significant contribution to the Sustainable Development Goals (SDGs). Many key aspects of Smart Specialisation are well aligned with the international discourse on the implementation of the 2030 UN Agenda for Sustainable Development. For example, the role of Science, Technology and Innovation in development, prioritisation and localisation, stakeholder engagement and resource mobilisation, co-investments and cooperation are relevant in both STI for SDGs roadmaps and S3 (UN IATT, 2020; Matusiak et al., 2020).

The Smart Specialisation concept is now being adapted to better suit the needs of national and local authorities in achieving sustainable development. The focus is on embedding the directionality and ambition of the Agenda 2030 into S3 priorities and objectives – considering the objectives of the EGD – and proposing adjustments to the S3 processes and governance to align them with the goal of systemic transformation underpinning the SDGs.

If, in the past, Smart Specialisation was predominantly focused on place-based economic transformation, more attention is currently being paid to sustainability aspects – economic growth that works for people and does not compromise our environment and planet. Within this framework, the European Commission is developing a concept of Smart Specialisation for Sustainable Development Goals (S3 for SDGs) that refers to place-based innovation-led transformation for growth and sustainability.

Although the Sustainable Development Goals (SDGs) require mobilisation across all governance levels, there is a strong consensus that they need to be localised to be addressed more effectively. The Reflection Paper on a Sustainable Europe by 2030 emphasises an important role of the regional and local dimension in the multi-level governance of sustainable development (European Commission, 2019). The national-level recommendations are included in the Annual Sustainable Growth Strategies (EU, 2020 and 2021).

S3, with its focus on fostering place-based economic transformation, appears as a suitable strategic framework and methodology for embracing and pursuing the SDGs and green and digital transitions. This potential has been identified by international organisations and countries as a promising vehicle for fostering sustainable development (UN IATT, 2020; Matusiak et al., 2020).

The objective of this paper is to develop conceptual and methodological reflections and guidelines for the design, implementation and monitoring and evaluation of S3 to achieve the SDGs. This work is based on insights and evidence collected through a literature review. The guidelines, accompanied by a self-assessment tool for regions, are to support their capabilities for designing and implementing Smart Specialisation strategies for achieving sustainable transformation.

This report first introduces the research objective and methodology within the policy framework of Agenda 2030 and Smart Specialisation. It then discusses the main insights from the literature review. The last chapter proposes the conceptual extensions and steps for aligning S3 with the SDGs. A draft version of the questionnaire for the self-assessment tool for the regions ('S3 sustainability check') is in ***Annex I***.

1. Research framework for S3 for SDGs

1.1. Research problem

The United Nations' 2030 Agenda for Sustainable Development encompasses 17 SDGs comprising societal, economic and environmental aspirational goals (United Nations, 2015). The Agenda is guided by several core principles. Firstly, the 2030 Agenda is *transformative*, explicitly aiming to shift the world onto a sustainable and resilient development path. This includes, for example, profound changes in production and consumption systems. Secondly, the SDGs are *indivisible and interlinked*, as the societal challenges underpinning the goals are interconnected and need to be addressed in a systemic way. Thirdly, the SDGs are *universal*, aiming to mobilise action in all countries across governance levels engaging multiple actors. Lastly, the signatories of the Agenda pledged that the socio-economic transformation needed to achieve the goals should 'leave no one behind' (ibid.). Actions taken to address the SDGs should aim at supporting the most vulnerable groups. They should ensure that they do not worsen the situation of already marginalised groups and that they do not create new ones.

This study investigates how the S3 concept and process could be best used to contribute to the achievement of the SDGs. The focus is predominantly on embedding the sustainability-oriented directionality and ambition of the Agenda 2030 into S3 and proposing adjustments to the S3 conceptual framework and process to align them with the ambition of systemic transformation underpinning the SDGs.

1.2. Research questions

The main research question of this study is: How can sustainability goals, notably the SDGs, be embedded in the S3 theoretical and conceptual framework?

In addition, the authors seek to answer five correlated questions, below, linked to the scoping and analysis of relevant literature and empirical material gathered.

- What types of innovation are most impactful in tackling societal challenges and addressing the SDGs in different territories and at different levels of governance, and specifically in the context of S3?
- What are the implications of embedding the SDGs and sustainability orientation in S3 for governance, leadership and the institutional setting of S3 (e.g. inclusiveness, incentives to engage, risk of capture)?
- What are the implications of embedding the SDGs and sustainability orientation in S3 for the Entrepreneurial Discovery Process (EDP)?
- What are the implications of embedding the SDGs and sustainability orientation in S3 for the design and implementation of policy instruments supporting S3?
- What are the implications of the SDGs and sustainability orientation for diagnosis, monitoring and evaluation in S3?

The questions are designed to collect relevant insights for the key S3 steps as laid out in the S3 manual (Foray et al., 2012):

- analysis of the regional context and potential for innovation,
- governance – ensuring participation and ownership,
- identification of priorities, definition of coherent policy mix, roadmaps and action plans,
- integration of a monitoring and evaluation mechanism.

1.3. Methodology

This study is primarily based on an extensive review of academic articles and selected technical reports. The authors also drew on active participation in a series of JRC expert workshops on the topic bringing together academic experts and interested regional and national stakeholders.

Scope and process of the literature review

This literature review aimed at offering insights into the implications of embracing the SDGs for the theoretical foundations and conceptual framework of S3. The review included theoretical and empirical studies on the role of place-based innovation for sustainable development. It comprised peer-reviewed articles published in academic journals as well as selected technical reports.

While the project did not intend to conduct a formal systematic literature review, the review followed a structured approach and replicable protocol (see ***Annex II***). The review followed a three-step review protocol:

- identification – phrase searches and filtering in academic databases (Scopus, ScienceDirect and Web of Science);
- eligibility and selection – screening abstracts and full texts, forward and backward reference checking, suggestions from consulted experts and the JRC;
- data analysis – analysis of the selected sample of documents based on structural coding and thematic queries.

Identification

The initial identification was based on keyword searches. The selected keywords and search phrases allowed articles explicitly connecting S3 and sustainable development as well as relevant positions connecting regional innovation and sustainability to be identified. The identification process included several iterations. The core queries were extended based on the screening of a small number of abstracts and full texts to capture relevant articles (***Table 1***). See ***Annex II*** for a detailed description of the process.

A basic query on S3 and sustainability was constructed as follows: ('smart specialisation' OR 'regional innovation strategy') AND (sustainable OR sustainability). To filter in documents explicitly referring to the SDGs, the search phrase was refined as: ('smart specialisation' OR 'regional innovation strategy') AND ('sustainable development goals' OR SDGs). To capture other relevant documents that do not mention Smart Specialisation explicitly but may address both issues related to regional economic development and sustainability (RQ2), the following extended query was run: (regional OR spatial OR local) AND (strategy OR policy) AND (innovation OR transition OR transformation) AND (sustainable OR sustainability). The extended query was then narrowed down as: (regional OR spatial OR local) AND (development OR strategy OR policy) AND (innovation OR transition OR transformation) AND ('sustainable development goals' OR SDGs).

The initial results were filtered to include articles published in journals covering the following subject areas of social sciences, humanities and arts, decision sciences, economics, business and management, environmental sciences and multi-disciplinary journals. Following the removal of duplicates, the list combining the results from all queries came to 637 documents.

Eligibility and selection

Abstracts of 637 documents were screened to se-

TABLE 1 *Phrases used for the literature search in academic databases*

	STRATEGIES AND POLICIES	SUSTAINABLE DEVELOPMENT
CORE LIST OF KEYWORDS	(('smart specialisation' OR 'regional innovation strategy' OR 'regional innovation policy')	('sustainable development goals' OR SDGs)
EXTENDED LIST OF KEYWORDS	(regional OR spatial OR local) AND (development OR strategy OR policy) AND (innovation OR transition OR transformation)	(sustainable OR sustainability)

lect positions explicitly addressing research questions from the review. Abstract screening initially limited the list to 145 positions. In the next step, we screened full texts of articles. This stage aimed to retain articles with the most significance to the objectives of the project and research questions as well as to reflect the diversity of theoretical backgrounds emerging from the review. Following the full text screening, the sample was reduced to 21 positions.

Forward and backward reference screening identified a further 73 positions which were added to the reference list. In addition, the team included journal articles and technical reports suggested by JRC researchers and selected academic experts. As a result, 14 additional positions were added to the list. The final list of references comprised 108 documents.

Data analysis

The selected documents were first structurally coded to identify research findings relevant to the research questions and insights for specific steps in the S3 process (i.e. prioritisation, diagnosis, governance, vision, actions plan, monitoring and evaluation). The second cycle of data analysis allowed the main emerging theoretical and conceptual frameworks relevant to aligning S3 with the SDGs to be distinguished.

EXPERT FEEDBACK AND STAKEHOLDER ENGAGEMENT

Researchers and practitioners were consulted throughout the process to seek feedback and ensure the validity of the study. The consultations included:

- interviews with selected scholars to help with scoping the literature review;
- the presentation of the initial findings from the literature and the building blocks of the conceptual framework at the SMARTER conference on 10 November 2020;
- a validation workshop with academics, scientists and experts in the field together with the representatives of the European Commission services.

2. Literature review

There is an expectation that Smart Specialisation Strategies (S3) foster the transition towards sustainability in Europe and make a significant contribution to the Sustainable Development Goals (Demblans et al., 2020). The S3 approach has already been presented as a useful framework and methodology to inform national and local strategies and policy roadmaps addressing the SDGs (UN IATT, 2020; Matusiak et al., 2020).

This literature review aims at offering insights into the implications of embracing the Sustainable Development Goals (SDGs) on the theoretical foundations and conceptual framework of S3. At the time of review, we found a handful of articles with a primary focus on S3 and the SDGs. For example, Polido et al. (2019) analyse the degree of embeddedness of the sustainable development discourse in S3 using the Portuguese Centro Region as a case study. Gifford and McKelvey (2019) propose that local knowledge-intensive entrepreneurship needs to be supported by S3 to develop new knowledge relevant to the achievement of the SDGs. While there is limited explicit focus on the SDGs, there has been a wealth of research and a variety of conceptual approaches applied by scholars to study the role of regional innovation strategies and policies in fostering sustainable development. Therefore, the basis for this review was extended to capture these broader perspectives.

To prepare the ground for selecting theoretical and conceptual insights relevant to S3 for SDGs, the review opens with the key issues raised in the recent critique and debate on S3, highlighting issues relevant to aligning the S3 concept with the Agenda 2030. Secondly, the review introduces selected emerging theoretical perspectives and concepts relevant to addressing sustainability challenges in S3. The review is structured in such a way so as to discuss the implications and insights from three broad theoretical perspectives emerging in the papers: sociotechnical transitions, social-ecological resilience and challenge-led innovation policies and governance. Lastly, key lessons learned from reviewing the frameworks are drawn for the original S3 methodology (Foray et al., 2012).

2.1. Origins, critique and evolution of the S3 concept

2.1.1. The concept of Smart Specialisation

Smart Specialisation is a place-based framework for innovation based on primarily evolutionary economics and new approaches to industrial policy. S3 is based on three key principles (Foray et al., 2009): prioritisation, structural transformation and the Entrepreneurial Discovery Process (EDP).

The first principle is about generating a density of actors and interrelated cross-sectoral projects dedicated to specific priorities. The second is about ensuring that these activities foster structural transformation of the regional economy. The EDP is considered a collective bottom-up process of continuous 'discovery', learning and adaptation as the transformation process unfolds. The concept originates from the new industrial policy literature (Hausmann and Rodrik, 2003; Rodrik, 2004; 2008). Foray (2015) later defined Smart Specialisation as 'the capacity of an economic system (a region for example) to generate new specialities through the

discovery of new domains of opportunity and the local concentration and agglomeration of resources and competences in these domains'.

Structural transformation of the regional economy is at the core of the concept. Foray et al. (2012; Foray, 2015) proposed four interconnected pathways of structural change which can be fostered by S3, including:

- *transition from an existing sector to a new one* – Transition is based on cooperative institutions and processes (i.e. the collective R&D, engineering and manufacturing capabilities) that form the knowledge base for development of the new activity;
- *modernisation of existing industry* – Modernisation can take place through the technological upgrading of an existing industry, involving the development of specific applications of new technologies to improve efficiency and quality in an existing sector;
- *diversification of regional economy* – Diversification happens when discovery leads to potential synergies (economies of scope and spillovers) which are likely to materialise between an existing activity and a new one;
- *radical foundation of a new domain* - The discovery here is that R&D and innovation in a certain field can make previously low growth activities suddenly become attractive. Such a radical foundation often involves the co-emergence of R&D and innovation and related entrepreneurial activity in a niche market.

2.1.2. Recent critique and evolution of the concept

The concept and its uptake in EC policies and guidebooks have been the subject of criticism. The recent critiques by Hassink and Gong (2019), Benner (2020) and consequent responses from the S3 'conceptual father' Dominique Foray (2019, 2020) raise many points directly relevant to preparing a conceptual framework for S3 addressing the SDGs.

Hassink and Gong (2019) put forward six criticisms of S3: the lack of conceptual clarity, notably the relation between specialisation and diversification; dominant focus on conventional science and technology (S&T); potential overlap with cluster policies; limited transformative potential of the EDP; limited benefits for structurally weaker regions; and weak measurement systems and practices.

Benner (2020) added to this criticism by raising additional points, in particular the narrow focus on R&D; problems with addressing the appropriate spatial scale; the one-size-fits-all methodological approach; insufficient focus on the process and implementation; ensuring realistic expectations and not overloading it with new asks (e.g. SDGs); and the need for simplification of regional innovation policy.

Bailey et al. (2018) offered a relevant critique and perspective on S3, arguing that the concept should explicitly integrate value creation strategy to build 'regional sustainable advantage'; sustainable is understood here as 'lasting'. The authors propose four steps that regional authorities should take to form more effective partnerships with the private sector to co-create and capture value. Firstly, much in line with S3, they should take a decision on whether to compete based on their existing strengths and assets or to develop new advantages in new specialisations. Secondly, they should identify and enhance key 'vehicles' or levers which can be used to build and sustain regional international competitiveness (e.g. inward foreign direct investment or anchoring multinational firms within a regional ecosystem). Thirdly, the region has to select how to position itself in relation to other regions – 'place positioning' – to foster value co-creation and capture. Fourthly, regions should specialise within global value chains and strive to be positioned as critical players whose position is difficult to undermine. The latter allows them to capture a significant proportion of globally co-created value. The contribution of Bailey et al. (2018) is relevant to S3 as a framework for building regional competitive advantage based on green technologies or products. Its understanding of structural change, however, is guided solely by

economic concerns, and does not address social and environmental aspects.

Foray (2019, 2020) decided to respond to the critique himself, offering clarifications and his views on the evolution of the concept. He pointed out the need to be clear about what the critique concerns, i.e. the concept as presented in the S3 guide (Foray et al., 2012), the later evolution of the concept and related theories in the academic debate or the formulation and implementation of the S3 strategies on the ground. The purpose of this paper is not to enter into the general S3 debate, but to highlight the points which are directly relevant to making S3 fit for fostering sustainability transitions and addressing the SDGs.

2.1.3. Key challenges for aligning S3 with the SDGs

The recent academic debate allows several characteristics of the S3 concept and practice to be highlighted, which need to be considered to make S3 most fit to address the transformative ambition of the Agenda 2030 and the SDGs. There are political, conceptual and implementation challenges to align S3 with the SDGs. This study considers all types of challenges with a particular focus on the conceptual and implementation challenges, notably considering known challenges in proposing key elements of the new framework.

Political challenges

The SDGs are normative goals rooted in a larger vision of future development. They require a strong political commitment and leadership across governance levels to mobilise collective action. To be become an effective vehicle for place-based innovation for the SDGs, Smart Specialisation needs a strong political backing. Although SDGs are part of the EGD, they are not binding objectives (however, the EU made a clear commitment to achieving them). The political and policy context in which the concept had first been introduced meant, in practice, that the overall focus was on driving economic growth and building regional competitive advantage. This is still the dominant interpretation by implementing authorities and any experts. While prioritising economic growth and competitiveness may align with individual SDGs, it is bound to neglect important aspects of the (indivisible!) Agenda 2030 and may lead to selecting specialisation areas disconnected from, or even in conflict with, many SDGs.

Conceptual challenges

Adding a strong sustainability orientation to the S3 concept would have considerable implications for substantive and procedural elements of the approach. The key challenge is to embed the SDGs as overall goals and a shared 'direction of travel' into a conceptual S3 design. S3 appears well suited to assume a mission-oriented approach as it is designed to identify and prioritise selected specialisation areas. Foray (2018) argues that as a non-neutral and directional strategic framework, S3 can be considered the part of a bigger family of mission-oriented policy approaches.

Another challenge is responding to the transformative ambition of the Agenda 2030 and the SDGs. The concept of S3 was conceived to foster structural transformation to improve regional economic performance. Foray (2019) maintains that the duality of transformation and specialisation at the core of S3 is what makes it particularly well positioned to foster the process of transformation.

The limited transformative potential of S3 was, however, one of the strongest criticisms of S3 (Marques & Morgan, 2018; Hassink and Gong, 2019; Benner, 2020). While transformation appears at the core of Smart Specialisation, the central concept of the Entrepreneurial Discovery Process (EDP) has been criticised for not being designed to provide sufficient theoretical and conceptual depth and breadth to address the challenge of structural transformation (Hassink and Gong, 2019). For example, the concept alludes to the need to achieve 'critical mass' but it does not explain the mechanisms of change and possible pathways to achieving it. The impact pathways proposed by Foray et al. (2012) do not say much about actor and temporal dynamics of transitions. It may appear that the main focus of S3 is on

identifying and supporting the emergence of local niches, but the approach is less robust when it comes to providing a framework for scaling up niches or constructing alternative development pathways.

Finally, to address the SDGs, the S3 concept will need to be extended from a primarily economic transition framework to consider and help foster social and environmental transformations. As a bare minimum, this means placing economic growth and productivity in a wider context of environmental and social change. But to address the underlying ambition of the SDGs, the concept should go beyond economic perspective and consider transformation as a systemic co-evolutionary process with interactions and interdependencies between economic, social and environmental dimensions.

Implementation challenges

Finally, S3 will need to be proved as an effective mechanism to make the changes happen on the ground. However, S3 has faced many implementation challenges (Marques and Morgan, 2018; Hassink and Gong, 2019; Benner, 2020). We have yet to see evidence that it has led to structural change. The limited evidence on the transformative impact of S3 needs to be seriously considered in designing and deliberating frameworks of the future generations of S3, especially in the context of addressing the SDGs.

Implementation challenges were especially felt in structurally weaker regions with limited competences and institutional capacities to design and implement effective innovation strategies and policies (Morgan, 2018; Marques & Morgan, 2018; Hassink and Gong, 2019; Benner, 2020). Weaker regions lack the capacity and competences to design and implement comprehensive and coherent policy mixes supporting transformation process. Foray (2019) recently admitted that, in practice, S3 may be best implemented in 'intermittent' regions and is less suited to the weakest and the most advanced regions. This is a particularly pertinent remark for this study. If S3 is not a universal approach, then its potential to address the SDGs is significantly limited, especially given that its implementation appears particularly challenging in less developed regions.

Some practical limitations appear to have been caused by the way the S3 concept has been communicated and interpreted by the regions. For example, S3 – in practice – tends to be dominated by a narrow understanding of innovation based on formal R&D and knowledge-intensive firms (Hassink and Gong, 2019). This may be partially caused by the associated EU funding, placing S3 investment under Thematic Objective 1 (Research and innovation) of the European Regional Development Fund and its portfolio of available instruments and categories of intervention. Some practice-oriented activities of the JRC, such as support for the implementation of S3 in EU's lagging regions or the application of the S3 concept beyond the EU, especially in the countries with lower institutional capacity (S3 in the EU Enlargement and Neighbourhood region), show that the application of S3 concept in this context requires more guidance and institutional capacity building but can bring positive results. On the other hand, successful application of the S3 concept in Norway (with a strong environmental and societal focus), Catalonia (with SDG orientation) or Northern Netherlands (with a strong focus on societal challenges) not only shows the usefulness of the approach for some advanced territories but also their capability to drive the methodology and its application forward. Foray (2018, 2019) argues that this limited understanding of innovation does not stem from the concept itself and that S3 should look beyond technological innovation. These 'translation problems', however, should be seen as integral to the concept design. These challenges need to be anticipated at the stage of (re) designing the S3 concept when it should be piloted and co-created with the regions.

TABLE 2 *Advantages and limitations of the current S3 model in addressing the SDGs*

S3 ELEMENTS	CURRENT S3 MODEL	STRENGTHS OF THE CURRENT MODEL	LIMITATIONS OF THE CURRENT MODEL
PRIORITIES IDENTIFYING THE PRIORITIES	Focus on creating regional competitive advantage Focus on concentrating resources on specific priority areas Top-down priorities stemming from the EU strategy and policies	Evidence-based approach to setting priorities based on regional assets and capabilities Building the strategic capacity to select priorities based on evidence and stakeholder engagement Potential to create greater impact by ensuring consistency of goals between regions	Limited consideration of the limits to a competitiveness-driven approach to address many sustainability challenges; limited focus on how to exploit regional potential to respond to global challenges and the SDGs Lack of explicit focus on sustainability goals and localising the SDGs Limited focus on localising the SDGs and ensuring shared ownership of goals locally
DIAGNOSIS ANALYSING THE INNOVATION POTENTIAL	Focus on the regional innovation system Focus on structural change and industrial transformation	Systemic approach to innovation process and good understanding of unique regional assets and capabilities Looking at long-term structural challenges in regional economies	Limited consideration of a wider socio-economic and socio-ecological system and limited focus on analysing regional impacts of global challenges Limited focus on the positioning of a region in international value chains relevant to fostering sustainable innovation Limited focus on sustainability transitions and local and global drivers and barriers of systemic transformation
GOVERNANCE SETTING OUT THE RIS3 PROCESS AND GOVERNANCE	Inclusive and participatory approach encouraging engagement of diverse stakeholders from business, academia and public authorities ('triple helix' approach) Supporting collective learning and interactions between stakeholders (Entrepreneurial Discovery Process) Approach combining top-down and bottom-up governance mechanisms Openness and support to interregional and macroregional collaboration in Europe	Strong emphasis on participatory approach based on the broad engagement and shared leadership of S3 Emphasis on developing institutional environment enabling collective learning and experimentation Nuanced approach to top-down and bottom-up mechanisms recognising the role of both Applications of S3 at various governance levels relevant to responding to challenges at scale	Limited focus on ensuring shared ownership of priorities and inclusion of marginalised groups or groups at risk of being impacted by new environmental, social or technological trends Limited focus on creating environment for more inclusive and/or problem-based or mission-oriented learning addressing sustainability challenges Bottom-up processes primarily limited to searching for solutions to top-down priorities The lack of coordination mechanisms between regions and between regions and other governance levels to address sustainability challenges in a collaborative way
VISION DEVELOPING A SHARED VISION AND SCENARIOS	Shared vision and scenarios Consideration of transition pathways	Strong emphasis on the shared vision and scenarios Consideration of different transition pathways focused on structural change	Limited emphasis on ongoing foresight allowing the debate on vision and scenarios to be nurtured Limited variety and narrow conceptualisation of transition pathways predominantly focused on industrial change rather than sustainability transitions Limited view of the role of inter-local and interregional collaboration in addressing societal challenges and the SDGs
ACTION PLAN DEFINING AN ACTION PLAN WITH A COHERENT POLICY MIX	Insistence on the role of a policy mix and policy portfolios Support for roadmapping as a specific procedural instrument to coordinate S3 Emphasis on supporting the experimentation of different types of innovation	Emphasis on ensuring policy coherence and that S3 is embedded in a wider policy mix Emphasis on formulating an action plan and concrete projects Emphasis on technological and non-technological innovation, including social innovation	Little focus on the implications of sustainability-oriented directionality for selecting and designing instruments The lack of a conceptual framework for a challenge-led roadmapping exercise addressing sustainability goals Limited emphasis on system innovation and integrated experimentation focused on system change
POLICY LEARNING MONITORING AND EVALUATING	Strong focus on monitoring and evaluation	Building monitoring and evaluation culture and capacities	No explicit focus on assessing the social and environmental impact of transition and on monitoring progress towards the SDGs Limited focus on reflexivity and policy learning

2.2. Theoretical and conceptual perspectives linking place-based innovation with sustainable development

Most regional planners and authorities apply diverse theories and concepts to inform development strategies and policies (Malizia et al., 2021). To embed SDGs in S3, planners need to revisit and broaden theoretical and conceptual frameworks underpinning both substantive and procedural dimensions of strategy development and implementation. The sustainability orientation creates new needs in terms of evidence, governance, innovation projects, instruments as well as monitoring and evaluation.

This section focuses on relevant theoretical perspectives and concepts emerging in the literature on how place-based innovation strategies can address sustainability goals. The review revealed diverse interdisciplinary approaches in addressing sustainable development in the regional innovation context. Broadly speaking, the literature review identified two broad approaches in the literature.

Firstly, there are well-researched approaches in regional economic development and regional innovation studies focused on green technology and eco-innovation. They typically use established theories and concepts from economic geography and innovation studies. These approaches include, for example, studies looking at environmental innovation with regional innovation system lenses (Cooke, 2010), ecological modernisation (Gibbs, 2006) or green industry development (Grillitsch and Hansen, 2019). They have paid limited explicit attention to the role of innovation and regional innovation policies in fostering the transformation of systems of production and consumption and wider sociotechnical shifts underpinning these transformations (Truffer and Coenen, 2012; Coenen et al., 2015; Grillitsch et al., 2019).

Secondly, there is emerging literature addressing the role of place-based innovation in addressing sustainability challenges in a systemic way and in fostering sustainability transitions. These studies employ concepts used in research on sociotechnical transitions, social-ecological resilience or challenge-driven innovation policy. They have different theoretical and conceptual foundations to traditional approaches to regional economic development and place-based innovation.

Given the transformative ambition of the Agenda 2030 and the SDGs, this review mainly focuses on the latter perspectives, which are more aligned with the transformative ambition of the Agenda 2030 and the SDGs. We believe they can offer useful insights into how to embed the SDGs and sustainability transition in S3. They may complement, but also challenge, the current theoretical and conceptual foundations of Smart Specialisation.

Based on an extensive literature review, we identified three broad theoretical and conceptual perspectives emerging in the reviewed papers:

- sociotechnical transitions
- social-ecological resilience
- challenge-led innovation policies and governance.

The selected perspectives are growing areas of research and a burgeoning academic debate (see e.g. Schot and Steinmueller, 2016; Köhler at al., 2019; Sovacool et al., 2020). They are broad research fields with approaches which often combine and blend many theories and concepts from various research traditions. Just to name one, multi-level perspective (MLP) in sociotechnical transitions is considered a middle-range theory and, therefore, remains open to conceptual elaborations (Geels, 2019) and 'bridging' with other research traditions.

As developing exhaustive reviews of these areas is beyond the scope of this paper, the following sections succinctly introduce three perspectives with a focus on drawing lessons relevant to revisiting the S3 concept.

Table 3 provides a schematic overview of these theoretical perspectives, their core concepts and examples of scientific work. Each of these perspectives and their possible contributions to S3 are

TABLE 3 *Selected theoretical perspectives and concepts emerging from the literature review*

PERSPECTIVES	CORE CONCEPTS	EXAMPLES OF PAPERS COMBINING PLACE-BASED INNOVATION, TRANSITION AND SUSTAINABILITY
Sociotechnical transitions	Sociotechnical system Multi-level perspective (MLP) Transition pathways Experimentation	Truffer and Coenen (2012) Coenen et al. (2012) Wieczorek et al. (2015) Hansen and Coenen (2015) Kivimaa et al. (2017) Sengers et al. (2019) Veldhuizen (2020) Binz et al. (2020)
Social-ecological resilience	Social-ecological system Transformational resilience Social learning	Eriksen et al. (2011) Brown (2014) Biggs et al. (2012, 2015) Colvin et al. (2014) Wamsler et al. (2014) Elmqvist et al. (2019) Bevilacqua et al. (2020) Castro-Arce and Vanclay (2020)
Challenge-led innovation policy	Transformational failures Transformative innovation policy (TIP) Mission-oriented innovation policy (MOIP) Responsible research and innovation (RRI) Policy mix for sustainability transitions	Weber and Rohracher (2012) Foray (2018) Tödtling and Trippl (2018) Magro and Wilson (2019) Fitjar et al. (2019) Uyarra et al. (2019) Thapa et al. (2019) Wanzenböck and Frenken (2020) Panciroli et al. (2020)

discussed in more depth in the following chapters. Each perspective is first described from a theoretical viewpoint, including its background and key concepts. This is followed by a discussion of governance frameworks, the role of experimentation and physical space. Finally, we present relevant insights and draw specific conclusions for Smart Specialisation.

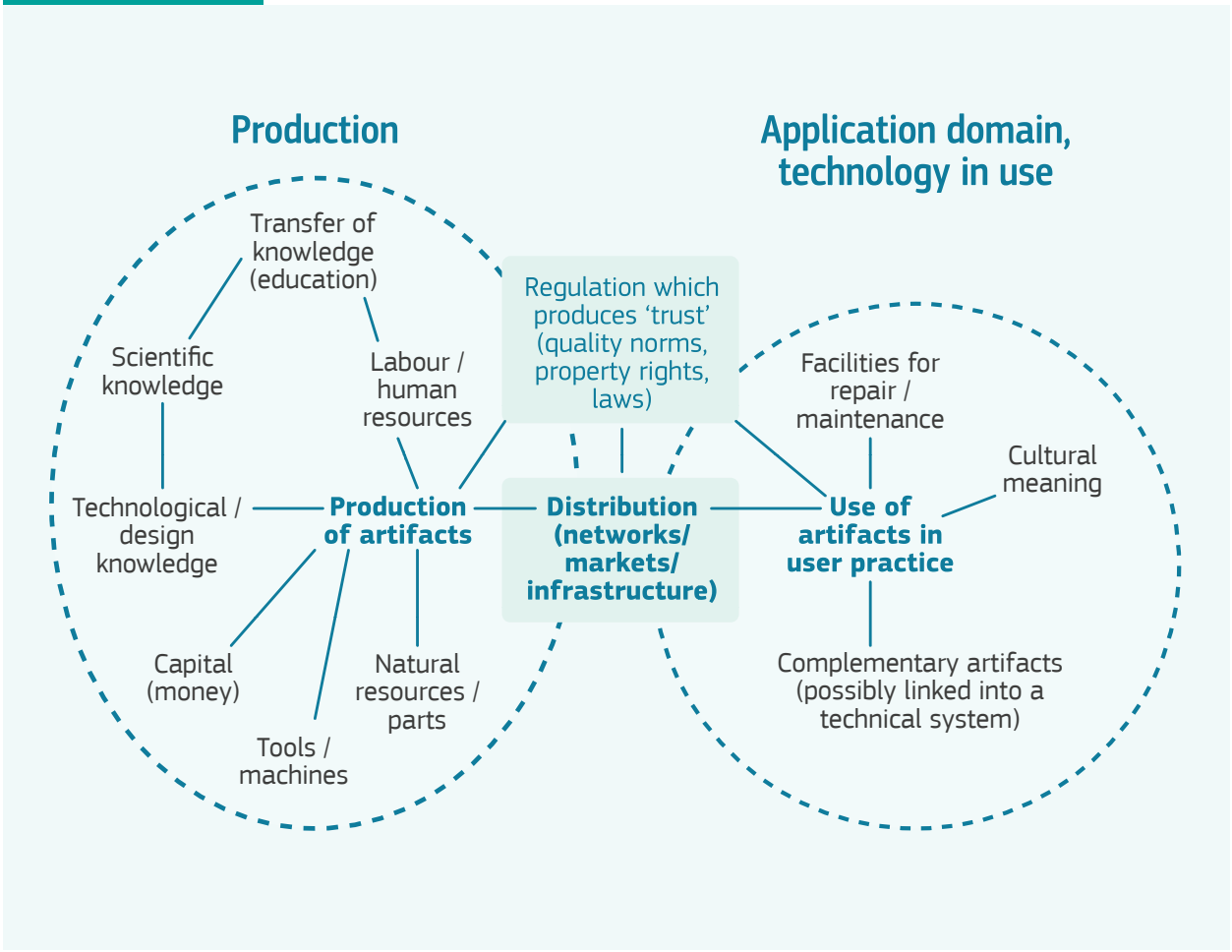
2.2.1. Sociotechnical transitions

THEORETICAL BACKGROUND AND KEY CONCEPTS

The sustainability transitions literature investigates processes of sociotechnical transition. The central concept of sociotechnical transition is a sociotechnical system. A sociotechnical system consists of multiple heterogeneous, tangible and intangible, elements that are linked together to fulfil societal functions such as the provision of food, mobility or shelter. The sociotechnical system perspective is a systemic multidimensional view of production, distribution and the use of products and technologies. The configuration and architecture of these elements and processes varies between systems. ***Figure 1*** provides a schematic representation of a sociotechnical system.

Multi-level perspective (MLP) is a core framework for analysing change in sociotechnical systems.

FIGURE 1 *Elements of a sociotechnical system*



Source: Geels, 2004

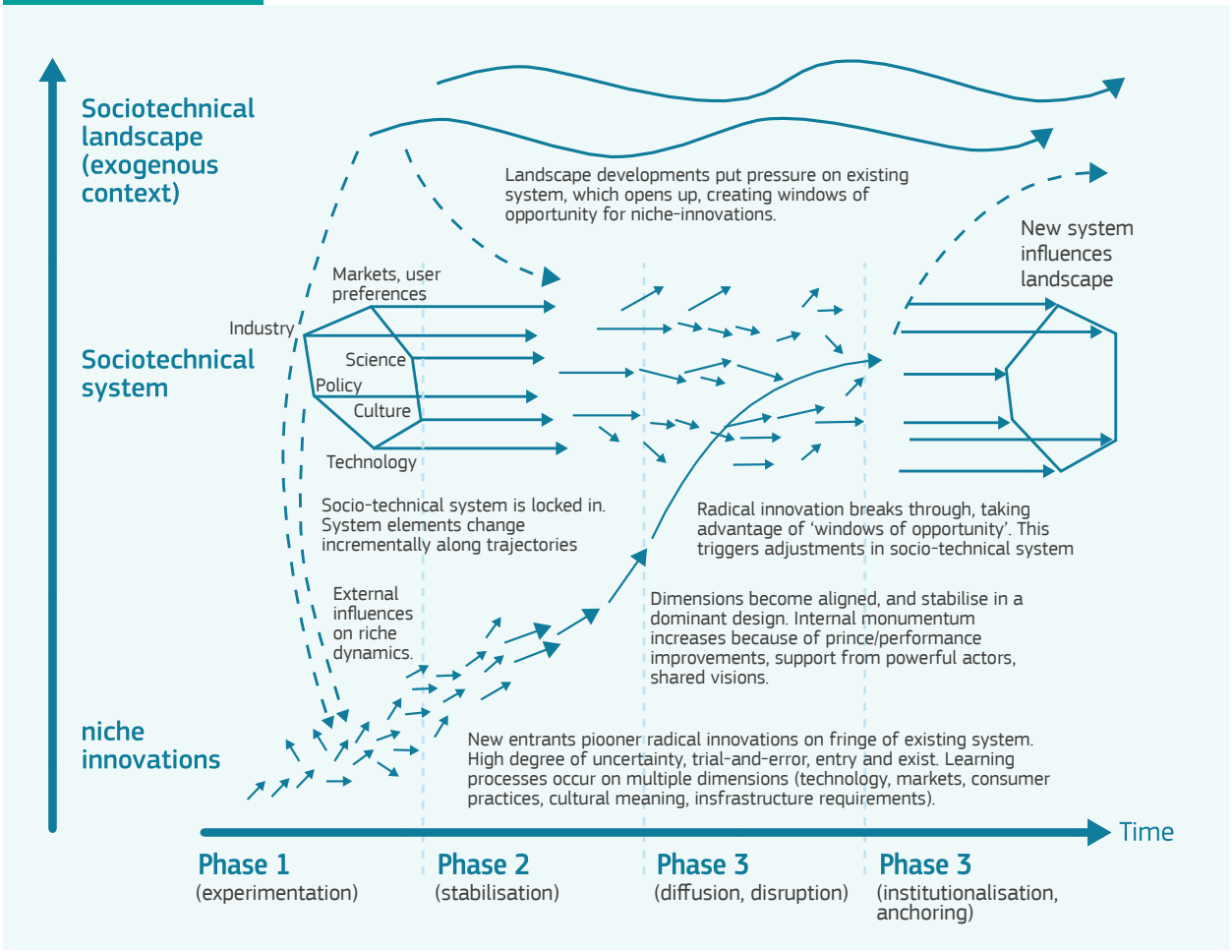
According to the MLP, transitions are shaped by the interplay of niches, regimes and landscape factors. Transition scholars introduced a notion of *sociotechnical regime* – a dominant and stable configuration in a sociotechnical system – to explain dynamics and mechanisms of change, as well as path dependency and lock-ins that evolve around technologies (see e.g. Kemp, 1994; Rip and Kemp, 1998; Geels, 2002). The MLP has roots in evolutionary economics, the sociology of innovation and neo-institutional theory but it has recently integrated insights from across the social sciences (Geels, 2019).

One of the most significant conceptual contributions MLP can offer to the S3 concept are conceptualisations and research on transition pathways which can complement and extend the current understanding of pathways in S3. Smith et al. (2005) distinguish four transition pathways considering the degree of coordination of adaptive response and the locus of resources, such as the creation of new knowledge and market formation, driving the transition (external or internal to regime).

Geels and Schot (2007) proposed a typology of pathways based on the nature of interaction between actors (alignment) and timing (or temporality). They distinguish four sociotechnical transition pathways, including transformation, substitution, reconfiguration and de-alignment and re-alignment. The typology was later reformulated by Geels et al. (2016) with a focus on endogenous enactment, identifying the main patterns for actors, formal institutions and technologies (see ***Table 4***).

Transition scholars have also started to research the processes of decline and destabilisation of regimes, which is particularly pertinent in relation to territories exposed and vulnerable to environmental or sociotechnical changes such as the re-

FIGURE 2 *Phases and level of transition in MLP*



Source: Geels (2019)

gions dependent on coal mining or heavy industry (Kivimaa and Kern, 2016).

THE ROLE OF EXPERIMENTATION FOR TRANSITIONS

Experimentation is a key process for sociotechnical transitions. For example, it is central in the MLP where it can foster bottom-up niche innovation or can be initiated at regime level (Geels, 2005; Schot and Geels, 2008).

Sengers et al. (2019) conducted a systematic review of experiments in the sustainability transitions literature, revealing a variety of normative orientations, theoretical foundations and conceptualisations. They differentiated between niche experiments, bounded sociotechnical experiments, transition experiments, sustainability experiments, grassroots experiments and experiments in urban settings. Based on the commonalities between different strands of literature, they define an experiment as 'conceptualized as an inclusive, practice-based and challenge-led initiative designed to promote system innovation through social learning under conditions of uncertainty and ambiguity.'

Sengers et al. (2019) also point to differences in approaches to experimentation, distinguishing between 'techno/managerial' and 'social/civic' perspectives. The former – primarily associated with niche experimentation and sustainability experiments –fosters the creation of markets to upscale new green technologies and seeks new sociotechnical alignments. The former – linked to a bounded sociotechnical experiment and grassroots experiment – focuses on social innovation engaging citizens. The techno/managerial experiments are closer to the S3 model. With the focus on sustainability goals, however, it could be argued that regions should engage more than previously with the more inclusive social/civic approaches to support social innovation.

There is limited evidence on the outcomes and impacts of experimentation[1]. An often-cited approach to conceptualising outcomes of experiments was introduced by Grin et al. (2010). The authors differentiated between three mechanisms:

- *deepening* - learning as much as possible from the transition experiment;
- *broadening* - repeating an experiment in an adjusted form in a different context; and
- *scaling up* - embedding an experiment in the structures of the incumbent regime.

Kivimaa and colleagues (2017) conducted a systematic review of various types of governance and policy climate experiments, such as niche creation, market creation, societal problem solving and spatial planning. The study revealed diverse outcomes and the impact of experiments ranging from changed discourse to the emergence and diffusion of innovative technologies or direct changes in the built environment. The authors found that experiments have most often led to deepening, less often to broadening and least often to scaling up. The impact of reviewed experiments appeared modest or incremental rather than disruptive. Kivimaa et al. suggest that, in order to lead to a more transformative impact, there is a need for a systematic deliberate combination of different types of experiments. Furthermore, there is a need for more empirical research on governance and policy experiments.

The findings are sobering and need to be seriously considered when setting goals, designing but also when managing expectations concerning the transformative impacts of S3, especially in the context of the ambitious SDGs. To increase the likelihood for scaling up there is a need to ensure the correct project scale itself as well as embed it in the wider policy mix.

Policy and governance frameworks supporting sociotechnical transitions

Sociotechnical transition research inspired the design and application of policy frameworks, notably Transition Management (Rotmans et al., 2001; Loorbach, 2010) and Strategic Niche Management (Kemp et al., 1998; Schot and Geels, 2008; Raven et al., 2010). Both frameworks can provide inspiration and practical insights for the design and governance of S3. In fact, the core concepts and policy approaches from sociotechnical transitions have strongly influenced the current thinking on transformative innovation policy (see ***Section 2.2.3***).

Transition Management (TM) comprises a conceptual framework and its own instruments and tools such as transition arenas, transition scenarios, transition experiments and transition monitoring. The approach originates from the Netherlands but is now applied in many countries and regions to support the governance of sustainability transitions. The approach, especially transition arenas, proved successful in opening up discourse, creating new networks and experiments (Loorbach et al., 2017) but its applications have not yet led to large-scale systemic changes (Loorbach et al., 2016). In a recent paper, Veldhuizen (2020) conducted a critical analysis on the potential alignment between S3 and Transition Management looking at the case of S3 in Gippsland (Australia). She pointed to some key limitations of S3 as a framework to foster transformative change towards sustainability, including the lack of a sufficient focus on transition pathways, a dominant focus on economic growth or insufficient reflexivity.

Strategic Niche Management (SNM) is an approach to design and deliberately manage niche formation processes through experiments (Kemp et al., 1998; Schot and Geels, 2008; Raven et al., 2010). The approach calls for integrated experimentation focused the co-evolution of technological applications and their context (e.g. user preferences, expectations, regulation). The logic of the approach is that such real-life experiments can stimulate deeper societal embedding of technology and foster transition pathways.

1 *For research on urban sustainability-oriented experimentation in living labs, see Bulkeley et al. (2016) and Coenen (2019).*

TABLE 4 *Transition pathways by Geels et al. (2016)*

Transition pathway	Actors	Technologies	Rules and institutions
Substitution	New firms struggle against incumbent firms, leading to overthrow	Radical innovations substituting existing technology	Limited institutional change, implying that niche innovation needs to compete in the existing selection environment ('fit-and-conform', 'incremental adjustment', 'layering')
	Different kinds of new entrants (e.g. citizens, communities, social movement actors, incumbents from different sectors) replace incumbents		Creation of new rules and institutions to suit the niche innovations ('stretch-and-transform', 'disruption', 'displacement')
Transformation	Incumbents incrementally reorient by adjusting search routines and procedures	Incremental improvement in existing technologies (leading to major performance enhancement over a long period) Incorporation of symbiotic niche innovations and add-ons (competence-adding, creative accumulation)	Limited institutional change ('layering')
	Incumbents substantially reorient to radical new technology or, even more deeply, to new beliefs, missions and business models	Reorientation towards new technologies: (a) partial reorientation (diversification) with incumbents developing both old and new technologies; (b) full reorientation, leading to technical substitution	Substantial change in institutions ('conversion', 'displacement')
Reconfiguration	New alliances between incumbents and new entrants	From initial add-ons to new combinations between new and existing technologies; knock-on effects and innovation cascades that change system architecture	From limited institutional change ('layering') to more substantial change, including operational principles ('drift', 'conversion')
De-alignment and re-alignment	Incumbents collapse because of landscape pressure, creating opportunities for new entrants	Decline of old technologies creates space for several innovations which compete with one another	Institutions are disrupted by shocks and replaced, possibly after prolonged uncertainty ('disruption')

Source: Geels et al. (2016)

Kivimaa et al. (2017) point out that TM and SNM differ when it comes to their approach to experimentation. TM incorporates experiments initiated at regime level. The approach highlights the importance of the visioning process before engaging in experimentation, which makes experimenting more coordinated. On the other hand, SNM emphasises the bottom-up approach to experimentation, which opens up a variety of options. Experimentation is to ensure diversity, learning and new network development. A core assumption of SNM is that 'sustainable innovation journeys can be facilitated by creating technological niches, i.e. protected spaces that allow the experimentation with the co-evolution of technology, user practices, and regulatory structures' (Schot and Geels, 2008). At the same time, however, too much diversity may hamper innovation by fragmenting resource investments, generating uncertainty and risk and slowing down the emergence of stable rules (Schot and Geels, 2008).

The approaches to experimentation from the sociotechnical perspective have strongly influenced new generations of challenge-driven innovation policies. For example, Schot and Steinmueller (2016) argue that transformative innovation policy should enable experimentation with options 'beyond the narrow boundaries set by incumbents.' In order to be transformative and not end up as isolated single experiments, experimentation should be embedded in policy mixes, and be given a dedicated space in broader regulatory, organisational and institutional frameworks (Chataway et al., 2017).

One of the challenges in applying transition thinking to policy is measuring and evaluating transitions. Turnheim et al. (2015) propose a pluralistic approach to analyse and evaluate transitions, integrating three complementary approaches: quantitative systems modelling, sociotechnical transitions studies and initiative-based learning. They argue that such a pluralistic perspective in the evaluation of transition dynamics can offer new methodological approaches to monitoring and evaluating transitions pathways and be useful for improving public governance and private strategies. New approaches are needed to embrace complexity and uncertainties of transitions as well as invite more reflexivity and a multiplicity of viewpoints.

Place and space in sociotechnical transitions

The initial developments of the theoretical and conceptual frameworks were criticised for the insufficient elaboration of the role of physical space in transitions (Truffer and Coenen, 2012; Coenen et al., 2012; Raven et al., 2012; Lawhon and Murphy, 2011; Truffer et al., 2015; Hansen and Coenen, 2015; Binz et al., 2020). This led to the development of a field of geography of transitions which formed a bridge between evolutionary economic, institutional and human geography and sustainability transitions (Köhler et al., 2019). The field can become a space to deepen the theoretical engagement of transitions research with related social science disciplines (Binz et al., 2020).

The emerging field of the geography of transitions is set to translate and elaborate theories and concepts from the sociotechnical transitions to explain the spatial dimension of transitions, more specifically how place-specificity and scale influence transition pathways and how transitions travel and diffuse between places and at various levels (Hansen and Coenen; 2015). The focus of the field is on the multi-scalar, place-based and spatial factors and processes that influence transition dynamics (Tödtling & Trippl, 2018; Binz et al., 2020).

Coenen et al. (2012) point to two core contributions of the field: the importance of the institutional embeddedness of sociotechnical development within specific territorial spaces, and an explicit multi-scalar conception of sociotechnical trajectories. The authors argue that the advancement of the geography of transitions is key to better understanding the place-specific impacts of sustainability transitions, with a particular focus on the geographical unevenness of transition processes. The latter points are fundamental to accomplishing the SDGs.

Based on an extensive literature review, Hansen and Coenen (2015) identified and discussed five place-specific factors influencing transitions.

- Urban and regional visions and related policies
  - Urban and regional policies are central to facilitating the embedding and diffusion of niche technologies.
  - Policy generally aims to combine ecological goals with economic competitiveness (often stimulating the industrial development of cleantech industries).
  - The governance of transitions encompasses multiple policy areas; they are contested and negotiated between multiple public, quasi-public and private territorial actors.
  - Rather than considering visions as underpinned by a consensus among multiple stakeholders, these are contested and result from struggles and intermediation.
- Informal localised institutions
  - The development and diffusion of environmental innovations are conditioned by informal localised institutions.
  - Niche formation is embedded in localised social practices.
  - Informal localised institutions positively influence the regulatory push on the development and adoption of environmental regulation.
  - The importance of recognising differences in informal institutions, even within local or urban territories, resulting in struggles over sustainability visions.
- Local natural resource endowments
  - Resource scarcity stimulates investments in renewable energy.
  - Resource endowments influence choices between renewable technologies.
- Local technological and industrial specialisation
  - Industrial specialisation conditions the development of innovations necessary for sustainability transitions.
  - The extent of knowledge spill-overs in a region influences the ability of firms to develop environmental innovations.
  - Local industrial specialisation is often the outset for selective regional policy agendas, which in turn reinforce technological and industrial specialisations.
- The existence of a particular consumer demand
  - Engaged local end-users are central to local market creation.
  - Geographical proximity enables producers to obtain feedback from end-users for emergent niche technologies.

The review conducted by Hansen and Coenen (2015) confirmed the importance of place-specificity for studying transitions and contributed new insights into how local place-specificity can shape the formation of niches and the emergence of technologies at and across different levels. They found, however, that there is a need for more research on the spatial characteristics of regimes, which largely remain considered as homogenous across territories.

One important insight from this literature is that while niche formation is situated in the local context and depends on the physical proximity of actors and resources, it should not be approached as primarily local processes. The geography of transitions emphasises the co-existence and interdependence of local and non-local relationships within niches, confirming the need to adopt a multi-scalar perspective to study transitions (Coenen et al., 2012; Raven et al., 2012; Hansen and Coenen, 2015). Adding space to MLP allows, for example, for the mapping and analysis of how local innovation niches connect with national and global networks to obtain knowledge and resources as well as how actors active in local niches engage in international networks and vice versa (see Wieczorek et al., 2015).

This approach raises interesting considerations for S3, such as: is there a critical mass of local pro-

cesses and a level of connectivity with national and global networks that is particularly suitable for or unfavourable to sustainability transitions? Linking this question to the notion of timescales of public intervention (in the case of S3, seven-year EU programming periods), the concept of phase transitions – in particular, fractals in economics and urban and economic geography (see works by Denise Pumain) – could be considered. This approach could be applied to disaggregate the 'grand' transitions into timescales and phases imaginable, achievable for and attractive to local (and other) communities in order to maintain their motivation towards the achievement of the shared vision.

Köhler et al. (2019) point to new research opportunities for the geography of transitions. The authors call for the exploration of spatial differences between normative orientations of transitions, such as place-specific understandings of sustainability and sustainable development priorities within and between the global south and the global north. Similarly, a better understanding of what sustainability means in the context of S3 for different European territories is needed to foster inter-territorial alignment and contribute to a more effective implementation of the EGD and the SDGs. Binz et al. (2020) argue for stronger theoretical engagement with other social science disciplines, notably advances in evolutionary and institutional geography, in further elaborating the concepts of scale, space and place in transitions. The latter could create synergies relevant to developing a stronger theoretical and conceptual framework for sustainability oriented S3.

Insights for Smart Specialisation

Probably the most significant insights from sociotechnical transition research are the conceptualisations and discussion on the dynamics and mechanisms of the entire system change and transition pathways.

Firstly, a sociotechnical system is a more suitable perspective for analysing system-level changes needed to address the SDGs. Understanding the system change through the lenses of sociotechnical transition, especially in consideration of how it relates to place and 'travels' in space, offers a valuable theoretical perspective for S3.

Secondly, the multi-scalar approach to studying sociotechnical transitions is highly valuable for enriching the S3 diagnosis – in particular to better map and analyse the positioning of the region, notably its S3 priority areas – in a wider national and global system and transition processes. Coenen and colleagues (2012) argue that such trans-local and trans-national network relations, along with their institutional interdependencies, should be considered by regional policy makers. Combined with the value chain perspective (Bailey et al., 2018), this can be a useful approach for preparing diagnostics and designing support for internationalisation in S3.

Thirdly, the conceptualisation of transition pathways from the sociotechnical perspective can be useful for deliberating more robust and heterogenous transition pathways in S3. This is relevant to the discussion on the vision, elaboration of scenarios of structural change, as well as selecting priorities for S3.

- The sociotechnical perspective on pathways can be used to place transition pathways in S3 in a wider context of system change. It can be used to further elaborate existing pathways as well as consider alternative routes for S3 to mobilise new actors and collaborations relevant to achieving sustainability goals.

- The approach to transition pathways from the sociotechnical perspective allows the critical interrogation of the roles of various actors and their interactions, including potential disagreements, conflicts and difficult negotiations between incumbents and new niche actors, including social movements. It emphasises the risk of contestation and conflict in the process. The latter is not sufficiently elaborated in the S3 framework, which hinges on largely collaborative and non-conflictual views on transition.

Table 4 illustrates how intersecting the typology of pathways proposed by Geels and Schot (2007) and Foray et al. (2015) yields new questions for the S3 deliberation which may open up alternative transition pathways in S3. These questions broaden the understanding of system change in S3, which is necessary to address transformative societal goals such as SDGs (Schot and Steinmueller, 2018). The discussion on sustainability transitions pathways could be further enriched by making explicit links with research on development pathways (see e.g. Grillitsch and Sotarauta, 2020; Jolly et al., 2020).

Fourthly, the critical research on the role, design and outcomes of different types of place-based experiments for transition offers valuable insights for sustainability-oriented S3. S3 should link the approach and design of experimentation to the nature of addressed challenges and transition pathways. For example, regime-initiated experiments based on a broad consensus are likely to be more effective in fostering modernisation based on technological substitution. On the other hand, a more bottom-up mode of experimentation will be better for seeking new niches focused on more radical innovation.

Last but not least, the policy frameworks rooted in the tradition of sociotechnical transitions, such as TM and SNM, can provide many practical insights for the design and governance of S3 – in particular by adding greater attention to the role of agency in policy and governance. For example, the instruments of TM, such as transition arenas and scenarios, could add a transformative ambition to the visioning and scenarios in S3, whereas the systemic approach to designing and running experiments in SNM could inspire different design instruments supporting experimentation in S3 (e.g. linking on-the-ground experiments with policy experimentation).

Table 5 summarises relevant insights and useful concepts and tools from sociotechnical transitions for S3 focused on the SDGs. The table also points out limitations and challenges for these insights when used in policy and planning practice.

2.2.2. Social-ecological resilience

Theoretical background and key concepts

Social-ecological resilience was traditionally understood as the capacity of a system to withstand change while maintaining essentially the same identity (Biggs et al., 2012). The traditional approach was criticised for being passive when faced with external shocks. Critics argued that more attention should be paid to the capacity of a system to actively reconfigure itself to anticipate and withstand emerging and future pressures. In response to this observation, resilience is increasingly approached as the capacity to absorb shocks while pursuing new development pathways. Resilience is seen as a trade-off between adaptation (changes within pre-existing systems and pathways) and adaptability (the ability to develop new pathways) in a situation of structural change (Bevilacqua et al., 2020).

The concept of resilience was also criticised for not paying enough attention to the dynamics of social change, notably politics, conflicts and power relations (Leach, 2008; Smith and Stirling, 2010; Brown, 2014). This section focuses on approaches to social-ecological resilience that place social dynamics and transition challenges at the heart of the concept.

One core concept underpinning socio-ecological resilience is a *social-ecological system* (SES). SES has its theoretical roots in complex adaptive systems. Resilience researchers study the dynamic interactions, interdependencies and changes in co-evolving social and ecological systems (Folke et al., 2016). A change of SES can take place in a process of *adaptation or transformation* (Biggs et al., 2012). Adaptation concerns the capacity of a system to deliberately respond to changes caused by external drivers or internal processes, either in anticipation of or in reaction to change. Adaptation does not significantly alter the dominant feedback mechanisms within an SES. Transformation, on the other hand, implies a more profound change that recombines multiple elements and feedback within an SES (Elmqvist et al., 2019).

TABLE 5 *Juxtaposing industrial transition pathways and sociotechnical transition perspective – new insights and questions for S3?*

STRUCTURAL TRANSFORMATION PATHWAYS IN S3 *(FORAY ET AL., 2012; FORAY, 2015)*	TRANSITION PATHWAYS OF SOCIOTECHNICAL SYSTEMS *(GEELS AND SCHOT, 2007)*			
		TRANSFORMATION *Actors* - Substantial reorientation of incumbents *Interactions* - Outside pressure, adjustment of regime rules	**SUBSTITUTION** *Actors* - New firms struggle against incumbent firms *Interactions* - Innovations by new firms compete with incumbent technologies	**RECONFIGURATION** *Actors* - New alliances between incumbents and new entrants *Interactions* - Cumulative change based on the adoption of innovation from new suppliers	**DE-ALIGNMENT & RE-ALIGNMENT** *Actors* - Incumbents collapse because of landscape pressure; new niche actors emerge *Interactions* - Multiple novelties challenging incumbents. New entrants compete for resources and legitimacy
	TRANSITION FROM AN EXISTING TO A NEW SECTOR *Actors* - Incumbents and new entrants *Interactions* - Collaborative effort to form the knowledge base for developing a new activity	What is the role of regional incumbents in fostering or blocking knowledge collaborations? To what extent is a transition from an old to a new sector driven by incumbents?	What are the dynamics and relations between new firms and incumbents involved in the transition from an existing to a new sector (collaboration, competition)?	To what extent does a transition to a new sector depend on new alliances between incumbents and new entrants?	To what extent does a transition from an existing to a new sector of existing industrial base pioneer, respond to or anticipate wider system de-alignment and re-alignment (e.g. shift from fossil fuel- to renewable energy-based energy system)?
	MODERNISATION OF EXISTING INDUSTRY *Actors* - Incumbents with inputs from new entrants *Interactions* - Technological upgrading of an existing industry based on applications of new technologies	What is the role of incumbents in fostering or blocking the modernisation of existing industries in the region?	What are the dynamics and relations between new firms and incumbents involved in the process of technological upgrading in the region (collaboration, competition)? To what extent does modernisation lead to technological substitution?	To what extent can the modernisation of existing industrial bases lead to a wider system reconfiguration (e.g. shifts in supply and value chains)? What is the role of new alliances in fostering cumulative technological upgrading in the region?	To what extent does the modernisation of existing industrial bases respond to or anticipate wider system de-alignment and re-alignment (e.g. shift to low-carbon, resource-efficient manufacturing)?
	DIVERSIFICATION OF REGIONAL ECONOMY *Actors* - Incumbents and new entrants *Interactions* - Synergies between existing and new activity (economies of scope, spill-overs)	What is the role of incumbents in fostering or blocking collaborations aiming to diversify regional economy? To what extent does modernisation lead to technological substitution?	What are the dynamics and relations between new firms and incumbents involved in collaboration aiming to diversify regional economy? To what extent does modernisation lead to technological substitution?	What are the dynamics and relations between incumbents and new entrants in collaborations aiming to diversify regional economy?	To what extent does the diversification of existing industrial bases respond to or anticipate wider system de-alignment and re-alignment?
	RADICAL FOUNDATION OF A NEW DOMAIN *Actors* - New entrants *Interactions* - R&D and innovation make low-growth activities attractive. Co-emergence of R&D, innovation and entrepreneurial activity in a niche market.	What is the role of incumbents fostering or blocking new niches experimenting with radical innovation (e.g. health research)?	What are the relations between new niches advancing radical innovation and incumbent firms in the region (collaboration, competition, capture)? To what extent can niches become testbeds for radical technological substitution?	To what extent can the niche-level changes lead to reconfiguration of the sociotechnical system?	To what extent do new niches advancing radical innovation pioneer, respond to or anticipate wider system de-alignment and re-alignment?

Transformations may start as changes of a single element but then lead to shifts of multiple elements in the system at various levels. There are interesting similarities here concerning the notion of transition pathways in sociotechnical transitions (see e.g. Geels and Schot, 2007).

Social-ecological resilience scholars identified seven principles for building systems' resilience (Biggs et al., 2012) which are relevant to local and regional actions:

Principle 1
Maintain diversity and redundancy;

Principle 2
Manage connectivity;

Principle 3
Manage slow variables and feedbacks;

Principle 4
Foster complex adaptive systems thinking;

Principle 5
Encourage learning;

Principle 6
Broaden participation;

Principle 7
Promote polycentric governance systems.

The literature search conducted for this study identified several articles focused on regional and local resilience in the context of sustainability challenges. Eriksen et al. (2011) propose a concept of *sustainable adaptation* which fosters socially and environmentally sustainable development pathways. Crucially, the authors emphasise that adaptation actions should be innovative and forward-looking: they should contribute to a more sustainable society and avoid locking people into high-emission and soon-obsolete technologies or practices. The latter implies that sustainable adaptation requires a capacity to influence future development paths or transition pathways.

Based on empirical observations from case studies, Eriksen et al. (2011) propose four principles to guide sustainable adaptation processes to foster local transformations:

- recognising the context of vulnerability;
- acknowledging that different values and interests affect adaptation outcomes;
- integrating local knowledge into adaptation responses; and
- considering feedback between local and global processes to foster transformation.

Although the four features focus on the challenges of climate change, they are able to guide regional actions addressing other societal challenges.

- The first principle implies recognising the importance of the specific context to develop a better understanding of how multiple stressors may impact the territory (region or locality).
- The second principle emphasises the importance of ensuring and institutionalising the representation of groups that are vulnerable to climate variability and change. Ensuring representatives of the process should be based on the analysis of power relations, potential conflicts and the vested interests of regional stakeholders.
- The third principle recognises that diagnosis and responses should be based on both local and external sources of knowledge about climate change or other relevant challenges. Authors emphasise that successful responses are built on diverse knowledge sources and varying understanding of risks and solutions within different local groups of stakeholders, including those directly exposed to risks.
- The fourth principle suggests the need to broaden local goals and actions from narrow short-term adaptation responses to link them to broader goals aiming to transform society through resilience and flexibility. This implies a recognition that local measures aimed at sustainability may have both positive and negative impacts and trade-offs inside and outside the region.

In a similar vein, Castro-Arce et al. (2020) offer a concept of *bottom-linked governance* based on the concepts of adaptive governance of SES, so-

TABLE 6 *Advantages and limitations of the sociotechnical transition perspective for embedding the SDGs in S3*

S3 ELEMENTS	INSIGHTS, CONCEPTS AND TOOLS RELEVANT FOR S3	CHALLENGES AND LIMITATIONS OF THE PERSPECTIVE
GOVERNANCE Setting out the RIS3 process and governance	Include MLP in stakeholder mapping Reflect on the roles, interests and expectations of incumbents and new niche actors in S3 governance (e.g. to anticipate and manage conflicts and capture)	Limited diversity in governance models, until fairly recently experimentation was one-size-fits-all. More recently, increased attention for policy mixes and the role of experimentation in a governance/policy repertoire
DIAGNOSIS Analysing the innovation potential	Sociotechnical system and transition pathways concepts Analyse the potential role of local/regional/national research and innovation actors in fostering the sustainability transition of key sociotechnical systems in your region (and beyond) Analyse profiles and interactions between regional incumbents and niche actors in sociotechnical systems addressed by S3 (e.g. are they focused on the SDGs?) Consider a long-time horizon in analysing sociotechnical transition Analyse the positioning of the region in global value chains	Sociotechnical system perspective does not allow for understanding wider social and environmental impacts Academic jargon may be difficult to follow for practitioners: the sociotechnical system approach needs significant investment in developing policy-friendly frameworks and operational language
VISION Developing a shared vision and scenarios	Concept of transition pathways (actors and interaction, temporal dynamics, systemic barriers and drivers) Use the concept of transition pathways in deliberating vision and scenarios (e.g. regime and niche actors, interactions and mechanisms, rules and institutions, role of innovation in disrupting and shifting away from dominant unsustainable regimes)	Limited focus on space and place dimension of transitions
PRIORITIES Identifying the priorities	Find a balance between prioritising sustainability-oriented niche innovations and the transformation of established specialisation areas Situate the SDGs in the regional and local context and consider wider regional and global dynamics of transition in identifying and scoping the S3 areas Consider interlinkages and trade-offs between economic, societal and environmental goals and their potential local and wider impacts	Where in S3 the rationale for priority-setting was fairly straightforward (derived from a competitive advantage logic), the logic for setting priorities becomes more heterogeneous and will be more informed by political processes and stakeholder interests weighing different sustainability goals – greater acknowledgement of trade-offs and dilemmas (e.g. between speed and diversity/inclusivity in transitions)

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>TABLE 6

S3 ELEMENTS	INSIGHTS, CONCEPTS AND TOOLS RELEVANT FOR S3	CHALLENGES AND LIMITATIONS OF THE PERSPECTIVE
ACTION PLAN Defining an action plan with a coherent policy mix	Develop dedicated spaces to encourage co-design and experimentation of system innovation, including governance and policy experimentation (lessons from applying the Transition Management and SNM approaches) and project portfolio approaches Importance of supporting internationalisation and interregional collaboration for niche development and experimentation Emerging research on the policy mix for sustainability transitions (see insights from research on transformative innovation policy)	Criticised as a tool tested in economically advanced and institutionally thick countries and regions
POLICY LEARNING Monitoring and evaluating	Need for formative and pluralistic approaches to the monitoring and valuation of transition pathways in S3 Empirical-based lessons learned on designing experiments to enhance social and policy learning	Requires strong analytical capacity and data Requires commitment and long-lasting engagement in the experimentation process from multiple stakeholders, including representatives of regional authorities

cial innovation and bridging organisations. They investigate how a regional governance system can be *transformed* into an adaptive system that facilitates bottom-up and top-down collaboration contributing to sustainable rural development. They argue that an adaptive governance approach can help envision and foster transformative change if it actively involves different actors; embraces diversity of values, interests, perspectives and management methods; and is able to effectively reconcile conflict. In this context, it can build on collaborative learning approaches to underpin knowledge-based consensus, thus actively affecting the behaviour of independent actors in the system. Further considerations contribute towards identifying the key actors in the system, whose change of behaviour will drive change among interconnected actors in their networks.

The combination of bottom-up and top-down collaboration bears a resemblance to the S3 concept, which also attempts to combine both of these governance modes and even mentions social innovation as an opportunity for S3 (Foray et al., 2012). In the bottom-linked governance approach, however, bottom-up processes are important throughout the process rather than being invoked primarily to respond to already-set priorities. The approach emphasises that sharing power and decision-making in the process can empower all actors and build trust (Castro-Arce et al., 2020).

Elmqvist et al. (2019) suggest an integrated approach to resilience bringing together and interlinking concepts of *resilience, sustainability and transformations*. Transformations involve changes in many dimensions including power relations, meaning and values, roles and routines. In this approach, resilience is understood from a dynamic perspective as the capacity to adhere and strengthen a specific transformation pathway rather than return to a previous state. Therefore, in order to manage 'directed' transformations, regions need to strengthen their resilience and capacity to deal with uncertainties. The article bridges socio-ecological resilience with sociotechnical transitions.

Insights for Smart Specialisation

Although resilience research has been criticised for offering a rather passive approach to adaptation, the review highlighted more recent approaches linking resilience and adaptation with a 'directed' transformation towards sustainability goals. Research on socio-ecological resilience, especially recognising the importance of 'social resilience', can offer many relevant insights for the new generation of S3 focused on sustainability –for governance and the EDP, in particular – and diagnosis underpinning S3.

Compared to the S3 model, the current social-ecological resilience perspective is based on a broader understanding of the system and its complex dynamics. The co-evolutionary perspective has its roots in complexity science and focuses on ensuring a long-term dynamic resilience of local *and* global social-ecological systems – long-term sustainability in other words – rather than concentrating primarily on building the economic competitiveness of a particular territory. Drawing a broader system boundary has implications on strategic goals and activities supported to foster transformations as well as the key actors and networks involved in the process.

The new perspectives combining resilience, transformations and sustainability are highly relevant to the S3 concept. The dynamic understanding of resilience as the capacity to stay on and strengthen a specific regional transformation pathway rather than return to a previous state (Elmqvist et al., 2019) is crucial. It offers a complementary perspective on the previously discussed typologies of transition pathways by pointing to the need to develop capacities needed to creatively adapt or transform the region.

Social-ecological resilience research emphasises the importance of considering and experimenting with a sufficient variety of innovations to respond to specific challenges and the need to consider the risks and uncertainties of choosing a particular innovation pathway. Integrating a long-term resilience perspective to address a complex and uncertain challenge in S3 may mean, for example, investing in several niches developing alternative solutions to the same challenge. This ensures diversity and redundancy and implies the acceptance of (apparent) short-term inefficiencies. It may seem like an overlap to a policy maker focused on short-term economic gain, but from the resilience point of view it is a good investment in emerging future opportunities and systemic risk reduction.

The resilience research emphasises the importance of social learning (similar to transition studies and SNM) and combining local and external sources of knowledge. There is a degree of alignment in the understanding of the importance of social learning in S3 and resilience perspective, even if the resilience scholars attach more significance to local knowledge and informal learning – including marginalised groups – than S3, predominantly focused on collaborative R&D and innovation. For the EDP focused on the local resilience challenges, it could mean extending the process to include the voices of those directly affected or at risk of being affected by these challenges. User-led innovation offers one way to include local voices and local knowledge in S3.

The resilience perspective offers many valuable insights into the governance, leadership and institutional setting of S3, notably the perspective of power and power relations and ensuring the broad representation of local stakeholders, including those marginalised and at risk. The issues of power and power relations are not richly elaborated in the S3 concept, even if their importance is recognised by the attention paid to the risk of capture and the observations made on a potential re-distribution of power among regional organisations which may be needed to set up collective S3 leadership. To address the SDGs and embrace an ambition of transformation, the S3 approach will need to be strengthened to include concrete actions to consider power and power relations in the strategy and its process. For example, to manage the risk of capture and empower underrepresented groups, the S3 stakeholder mapping and governance arrangements should consider the formal and informal power of stakeholders and create

TABLE 7 *Advantages and limitations of the social-ecological perspective on embedding the SDGs in S3*

S3 ELEMENTS	INSIGHTS, CONCEPTS AND TOOLS RELEVANT FOR S3	CHALLENGES AND LIMITATIONS OF THE PERSPECTIVE
GOVERNANCE Setting out the RIS3 process and governance	Ensure inclusivity of the process, in particular to include previously excluded groups (e.g. marginalised groups and groups at risk)	Less focus on the innovation process, science-industry interface and the role of incumbents As SDGs significantly broaden the group of relevant stakeholders, appropriate representation may become an issue. Broadening participation requires changes to the established approaches to identify and select stakeholders. The involvement of new stakeholders, especially vulnerable groups and groups at risk, increases the diversity of worldviews and may lead to new disagreements or even conflicts
DIAGNOSIS Analysing the innovation potential	Concepts of the social-ecological system, transformational resilience and a co-evolutionary approach to system change Include a longer-view perspective on the social-ecological system and the positioning of the region in the global eco-system Analyse the role of research and innovation to address societal challenges while ensuring transformational resilience Critical perspectives to better understand the frameworks and motivation of local actors, and how they interpret scientific evidence	The complexity of the social-ecological system and co-evolutionary dynamics require a strong analytical capacity. It will likely require investment in the regional institutional capacity, and broadening expert and research communities involved in S3 Academic jargon may be difficult to follow for practitioners
VISION Developing a shared vision and scenarios	Broaden the regional vision to include a socio-ecological perspective (e.g. navigating complexity and placing technological change in the wider social-ecological perspective) The transformative resilience perspective can be used in scenario development (e.g. resilience of transition pathways)	This may require investment in building a stronger in-house foresight capacity
Priorities Identifying the priorities	Engage local actors to develop shared ownership of strategies and to localise the SDGs The prioritisation process should focus on prioritising challenges related to SES and mobilising social and other types of innovation to address them	No specific focus on the process of strategic prioritisation in this perspective

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> TABLE 7

S3 ELEMENTS	INSIGHTS, CONCEPTS AND TOOLS RELEVANT FOR S3	CHALLENGES AND LIMITATIONS OF THE PERSPECTIVE
ACTION PLAN Defining an action plan with a coherent policy mix	Support local experimentation supporting social innovation	Limited focus on developing strategies and action plans at regional level. Limited focus on a policy mix
POLICY LEARNING Monitoring and evaluating	Add metrics and indicators on environmental and social outcomes and the impacts of S3 Emphasis on embracing the complexity and uncertainty of transformations Insights into how to design environments and enable social learning Include local knowledge and expertise in the design and implementation of projects	Including a social-ecological perspective in the monitoring and evaluation requires investment in the regional evaluation capacity

protected spaces which ensure that weaker stakeholders can voice their concerns and present their ideas. More inclusive forms for the S3 governance could draw on alternative governance approaches, such as polycentric governance, which call for more decentralised processes and institutional arrangements.

Lastly, the social turn in resilience research pointed to the key role of using critical interpretative perspectives and research methods to deepen the diagnosis and improve the reflexivity of the process. The transformation processes are likely to challenge and disrupt existing power relations, put pressure on the current roles and routines of regional stakeholders and communities and put worldviews and value systems to the test. The consideration of various frames, perspectives and interpretations of societal challenges and the need for a system change is key to agreeing on a shared vision, deliberating transition pathways and also has implications on assessing risks and the benefits of innovation.

Table 7 summarises relevant insights and useful concepts and tools from social-ecological resilience for the sustainability-oriented S3. The table also points out the limitations and challenges of these insights when used in policy and planning practice.

2.2.3. Sustainability-oriented innovation policy

EVOLUTION OF INNOVATION POLICY

There is a vivid academic debate on the role of innovation policy in addressing societal challenges and fostering transformational change towards a sustainable economy and society (Weber and Rohracher, 2012; Chataway et al., 2017; Mazzucato, 2018ab; Fagerberg, 2018; Schot & Steinmueller, 2016, 2018; Grillitsch et al., 2019). Scholars observe a shift in the overarching rationale and objectives of innovation policy towards addressing societal challenges and fostering systemic change towards sustainability, often with a focus on the SDGs (see e.g. UNCTAD, 2019).

In the context of this debate, Schot and Steinmueller (2016; 2018) introduced the notion of the 'three framings' of innovation policy. In the first framing, innovation policy responds to market

failure and supports science and technology to stimulate growth and competitiveness. In the second framing, the policy addresses system failures recognising the importance of a well-functioning innovation system to foster innovation. The third framing – 'transformative change' – responds to transformational failures and calls for an ambitious innovation policy to direct and foster sustainability transitions. This framing requires a multi-sectoral innovation policy reconciling economic, social and environmental goals with an overarching focus on sustainability. Authors emphasise that the framings can co-exist and that, in the real-world innovation policy, the boundaries between them may become blurred. Scholars warn, however, that current policy practices need to change profoundly to foster sustainability transformations (Sovacool et al., 2020).

The interest in the third framing can be also seen in the new approaches being promoted and applied by international organisations (e.g. OECD, 2015; UNCTAD, 2019), the EU (e.g. the focus on 'just transition' and industrial transitions in the European Green Deal or the mission-oriented approach in the Horizon Europe programme) and countries (e.g. the mission-oriented approach being tested in many OECD countries).

Legitimising transformative innovation policy – transformational failures

Weber and Rohracher (2012) argue that market and system failure arguments underpinning conventional approaches to innovation policy did not provide a strong rationale for policies to foster processes of transformative change to occur in a socially and politically desirable way. Market and system failures remain useful for addressing structural deficits in innovation systems but are insufficient, they add.

To legitimise adding transformative goals to innovation policies they proposed a new set of transformational failures strongly rooted in a sociotechnical perspective (Weber and Rohracher, 2012), as shown below.

- Directionality failure

Lack of a shared vision regarding the goal and direction of transformation; the inability of collective coordination of distributed agents involved in shaping systemic change; insufficient regulation or standards to guide and consolidate the direction of change; a lack of targeted funding for R&D and demonstration projects and infrastructures to establish corridors of acceptable development paths.

- Demand articulation failure

Insufficient spaces for anticipating and learning about user needs to enable the uptake of innovations by users; the absence of orienting and stimulating signals from public demand; a lack of demand-articulating competencies.

- Policy coordination failure

A lack of multi-level policy coordination across different systemic levels (e.g. regional–national–European or between technological and sectoral systems); a lack of horizontal coordination between research, technology and innovation policies and sectoral policies (e.g. transport, energy, agriculture); a lack of vertical coordination between ministries and implementing agencies leads to a deviation between strategic intentions and the implementation of policies; no coherence between public policies and private sector institutions; no temporal coordination resulting in mis-matches related to the timing of interventions by different actors.

- Reflexivity failure

Insufficient ability of the system to monitor, anticipate and involve actors in processes of self-governance; a lack of distributed reflexive arrangements to connect different discursive spheres, provide spaces for experimentation and learning; no adaptive policy portfolios to keep options open and deal with uncertainty.

The framework proposed by Weber and Rohracher (2012) is relevant to all governance levels, including the regions (Wanzenböck and Frenken, 2020), and can be directly used to (re)design and implement S3 focused on transformative system change.

Approaches to challenge-led innovation policies

There are several approaches to research and innovation policy with a broader focus on transformative change towards sustainability. We focus here on three: new mission-oriented innovation policy (MOIP), transformative innovation policy (TIP) and responsible research and innovation (RRI). All three approaches share the ambition of making innovation policy more directly engaged in tackling societal challenges and pursuing ambitious sustainability goals (e.g. SDGs). They differ, however, in their understanding of system change, the nature and agency types of different actors and the types and nature of innovations and social learning processes needed to foster transition.

Diercks et al. (2019) classify MOIP among policies characterised by a relatively narrow understanding of the process of change, often expressed in terms of academic- and industry-led technological revolutions. TIP or RRI is based on a broader conceptualisation of system change strongly influenced by a sustainability transitions agenda. This distinction may be considered rather crude, but it points to significant theoretical and conceptual issues which need to be reflected upon and discussed in the S3 design process.

Mission-oriented innovation policy (MOIP) introduced here is based on the approach popularised by Mariana Mazzucato (Mazzucato, 2018ab). MOIP is a systemic public policy approach that draws on frontier knowledge to attain specific goals (ibid.). The mission-oriented approach emphasises the importance of the direction towards transformation and economic growth, which requires the creation and shaping of new markets, not just correcting existing market failures. Mission-oriented policies should focus on creating system-wide transformation across many different sectors and value chains.

Mazzucato (2013; 2016) emphases the key role of the state as the only institution with the power to shape markets and direct economic activity in socially desirable directions to achieve publicly accepted outcomes. She emphasises industrial and innovation strategies and policies as pillars to achieve transformational societal change. These policies should identify and articulate new missions that can change production and consumption patterns across various sectors. MOIP requires new collaborative efforts between private and public actors, as well as an important role for civil society. Missions may require consensus-building in civil society, combining the need to set directions from above with processes of bottom-up experimentation from below.

Transformative innovation policy (TIP) can be defined as a systemic policy approach that aims to transform sociotechnical systems by fostering the radical reconfiguration of its elements and processes to meet sustainability goals (Schot and Steinmueller, 2016; 2018). TIP is a democratic, experimental and bottom-up process of directionality exploration (Sovacool et al., 2020). The TIP approach considers innovation policy from a whole sociotechnical system perspective and embeds at its core the needs of sustainability, environmental protection, equity and democracy (ibid.).

Schot and Steinmueller (2018) argue that sociotechnical system transformation is a very different goal to developing new radical technological solutions. The focus on cleaner substitutes of products, for example, does not address deeper systemic issues. Replacing ICE powered cars with ever-better performing EVs will lead to cleaner air but does not address many systemic mobility problems such as congestion or affordability and the accessibly of mobility services. The focus on new products and technologies, even if they are developed with social engagement, will not transform production and consumption systems and, as a consequence, will not deliver on ambitious SDGs (Schot and Steinmueller, 2018). This argument supports the critical reflection on the limitations of industrial transition pathways proposed for S3 in fostering deeper societal transformations.

Responsible research and innovation (RRI) is defined by the European Commission as a participatory approach to research and innovation which aims to better align the process and its outcomes with the values, needs and expectations of socie-

ty. The term 'responsible research and innovation' (RRI) appeared in Europe around 2011 during the drafting of the Horizon 2020 Framework Programme as the evolution of the term 'responsible research' employed in 2002 in the 6th Framework Programme (Panciroli et al., 2020). RRI was intended to promote ethical issues in FPs and the dialogue between various actors and activities in the research field. RRI covers six dimensions, notably governance, public engagement, gender equality, science literacy and science education, open access and ethics of scientific and technological developments. While the approach did not initially have an explicit focus on environmental sustainability (ibid.), the most recent RRI projects funded by the EC also address environment issues such as the anticipation of the potential environmental, health and safety impacts of R&I (EC, 2020).

The academic definitions of RRI based it on the critical approaches, notably Constructive Technology Assessment (Rip et al., 1998), Real Time Technology Assessment (Guston and Sarewitz, 2002), Upstream Engagement (Wynne, 2002; Wilsdon and Willis, 2004) and Midstream Modulation (Fisher et al., 2006) that seek to open up (Stirling, 2008) technological possibilities while they are still 'under construction'. Stilgoe and Guston (2017) highlight that RRI comes with the need to reframe the problems to which technologies are offered as solutions. In this way, as intended by the EC, the approach engages with the rhetoric on societal challenges and seeks to better align policy with societal needs.

Policy mix for sustainability transitions

Research on the role of policy mixes in directing and accelerating sociotechnical transitions towards sustainability has intensified in recent years (see, for example, Kivimaa and Kern, 2016; Kern et al., 2017; Rogge and Reichardt, 2016; and Kern et al., 2019 for a recent review).

Policy mixes are 'complex arrangements of multiple goals and means which, in many cases, have developed incrementally over many years' (Kern and Howlett, 2009). It is a systemic multi-actor, multi-level approach to policymaking which approaches public policy as an emergent, complex system of interventions, actors and processes co-evolving over a long period of time. Flanagan et al. (2011) emphasise the messy, complex and highly contextual nature of policy mixes and emphasise the need to develop a dynamic and situated understanding of processes by which policies 'emerge, interact and have effects.' Within the policy mix concept, policy instruments are considered in the context of a wider policy and regulatory and political context in which they are designed and implemented.

Reichardt and Rogge (2016) argue that an innovation policy mix for sustainability transitions needs to ensure that policy intervention as a mix contributes to a particular direction in transformative change. Directionality can be introduced to a policy mix by identifying major challenges in policy visions, setting specific policy goals and targets as well as translating those goals into criteria guiding policy implementation (see also Weber and Rohracher, 2012). In the context of innovation mixes for the SDGs, directionality means recognising social and environmental challenges as challenges integral to innovation policy and, more concretely, integrating them into strategic objectives, targets and implementation criteria for instruments throughout the mix.

Rogge and Reichardt (2016) proposed an extended policy mix concept to analyse policies supporting sustainable innovation in the context of sustainability transitions. They point out that most policy research has been based on a narrow definition of a policy mix seen as 'interacting instruments aimed at achieving objectives in a dynamic settings' (ibid.:1623). They argue that a policy mix approached from the point of view of sustainability transitions requires a broader scope to encompass its complexity, policy processes and the role of long-term strategies and targets. Rogge and Reichardt (2016) consider the policy mix as a combination of elements, processes and characteristics, which can be specified using different dimensions. Both elements and processes can be analysed through their characteristics, including in particular the consistency of elements, the coher-

ence of processes and the credibility and comprehensiveness of a policy mix. Policy mixes can be analysed in several dimensions, including policy fields, governance levels, geography and time.

Policy coherence becomes particularly important for polices aiming at enabling system innovation, as defined by authors, from sociotechnical transitions. This is because system innovation 'aims to achieve much more than coherence or policy alignment since it involves actors outside government – notably firms and civil society – and takes a longer-term view' (OECD, 2015). OECD (2015) emphasises that 'implementing a system innovation policy requires sophisticated analytical tools and processes in governments to model systemic problems, to understand casual relations among different elements of the system (e.g. between traffic, private car use and public transport), barriers and obstacles, and to design policy responses be they changes to legislation, regulations, standards or fostering technology platforms and public-private partnerships.'

The literature on S3 and policy mixes is limited. In a recent contribution, Magro and Wilson (2019) analyse the interaction between governance and policy mix evaluation in the context of S3 in the Basque Country. The paper argues that unpacking and understanding the impacts of policy mix is key to strengthening regional capacity for designing and implementing better innovation policies for transition. They argue that the usefulness and quality of policy learning underpinned by an evaluation process depend on whether evaluation is considered legitimate by key actors involved in the design of S3. Their analysis confirms the messy and complex nature of real-world policy mixes and challenges to ensure directionality at mix level. The policy mix in the region is characterised by the co-existence of various instruments, including neutral instruments, instruments designed with a strong directionality and instruments which were adjusted with new strategic goals.

Critical approach to the evidence base and learning

If public support for innovation is driven by a motivation to enable a wider sustainability transition, this needs to be reflected in the evaluation and monitoring system. Some argue that new metrics and appraisal criteria are needed to reflect the transformative ambition of public policies (Weber and Rohracher, 2012; Schot and Steinmueller, 2016). They also emphasise the role of reflexivity in policy development and evaluation. Policies should be based on interdisciplinary scientific advice, and should remain open for evidence challenging dominant views (Schot and Steinmueller, 2016).

Miedziński (2015; 2018) argues that developing an evidence base for transformative policies is not only about the technical capacity to collect data and analyse quantitative indicators, but is also about appreciating different interpretations of evidence, embracing risk and uncertainty and building a shared understanding among key stakeholders. This calls for an integrated approach to the monitoring and evaluation of policies.

Firstly, there is a need to critically reflect on assumptions and claims underlying codified knowledge in the evidence base of a policy (e.g. indicators, models, assessment methodologies). More critical attention is needed in the process of selecting, interpreting and *linking* evidence to policy arguments and policy visions. Policy makers and officials should explicitly take into account specific contexts and assumptions in which evidence used to support certain policy decisions is created and interpreted by different organisations. Policy makers themselves are not exempt from this critical reflection. Before engaging stakeholders, they should reflect on their own understanding of the challenges. Given that the policy vision is to be shared by a vast group of stakeholders, the process of selecting, treating and interpreting evidence needs to be transparent and, whenever feasible, participatory. This can contribute to building mutual trust in constructing future visions.

Secondly, there is a more fundamental need to rethink and re-organise the approach to generating and organising policy intelligence. The argument is to approach policy intelligence as a policy learn-

TABLE 8 *Challenge-oriented innovation policy following the principle of subsidiarity*

	SUBNATIONAL	SUPRANATIONAL
ASSUMPTION	Challenges specific to local circumstances	Challenges affecting all regions in similar ways
RATIONALES	Finding ways to tackle contextual problems Improving democratic decision-making Increasing variety Achieving multi-actor coordination	Avoiding free-rider problem Avoiding duplication Sharing risks Benefiting from economies of scale
SCALE	Small-scale and contextual solutions	Large-scale solutions requiring big investments
LEGITIMACY	Contested problem requiring responsiveness to citizens and multi-stakeholder participation in formulating needs and solutions	Uncontested problem with clear problem definition, often associated with need for scientific advancement, technology innovation and technology diffusion.

Source: Wanzenböck and Frenken (2020)

ing system rather than a system predominantly searching for instrumental validation of a given course of action. This means redesigning both approaches for gathering and interpreting evidence as well as for the wider institutional setting and organisational environment in which policy learning takes place. The former could imply enlarging theoretical and methodological bases of policy foresight, evaluation and impact assessment (to include interpretive approaches, amongst others). The latter is linked to a larger agenda of organisational and institutional change that would create better conditions for organisational learning within the policy organisation as well as engage wider learning communities involving external actors and stakeholders.

Considerations of the role of place and space in challenge-led innovation policies

There has been relatively little focus on the role of place and space in the research on challenge-led innovation policy. Coenen et al. (2015) also note that spatial perspective is still underrepresented in innovation policy discourse on societal challenges. The literature review identified several contributions focused on challenge-led regional innovation policy.

A multi-scalar view on the regional challenge-led innovation policy

In a recent paper, Wanzenböck and Frenken (2020) make a key contribution in this respect, discussing the role of innovation policies for societal challenges at subnational, national and supranational level from the perspective of subsidiarity. The authors argue that while broad societal challenges and goals, such as the SDGs, are best defined on an international level and should offer an overarching direction towards transition, regions and localities are best placed to articulate and translate these goals into their own strategies and policies, and to develop specific solutions suitable to their context. They differentiate between rationales of challenge-oriented innovation policy between subnational and supranational levels (see ***Table 8***).

Apart from major scientific breakthroughs and infrastructures, most global solutions will not be universally applicable and accessible to many regions; they are unlikely to become non-rival and non-excludable global public goods. Furthermore, given that the local embeddedness of many local innovations, they will be difficult to transfer across regions or countries. Challenge-oriented

regional innovation policy is, therefore, key to harnessing place-specific, fragmented and often tacit knowledge to develop a variety of local solutions to tackle societal challenges. But it should also support the engagement of regional actors in international networks and provide directed support to the adoption and embedding of solutions from outside the region.

Wanzenböck and Frenken (2020) further emphasise the key role of regions in enhancing the democratic legitimacy of innovation policy by engaging multiple local stakeholders, including groups most affected by societal challenges, in the process of translating broader societal goals to resonate with the local reality. This includes identifying, framing and formulating local interpretations of global definitions of global problems as well as engaging local innovators and citizens developing local solutions. The latter bears a strong resemblance to the previously discussed arguments from the social-ecological resilience perspective.

The approach proposed by the authors emphasises the multi-scalar nature of challenge-oriented innovation policy. While many solutions to local problems can be developed locally, the extensive global challenges should be outlined at national or supranational level. The coordination and monitoring processes need to be supported by trans-regional and multi-scalar institutions, allowing the evaluation of, learning about and exchange of good and unsuccessful practices.

Wanzenböck and Frenken (2020) argue that challenge-oriented regional innovation policy – as outline above – can be made a part of S3 but it requires investments in strengthening regional institutional capacities needed to design and implement policies.

S3 as a mission-oriented innovation policy

Joining the debate on the mission-oriented policy, Foray (2018) argues that, as a non-neutral and directional strategic framework, S3 can be considered part of a family of mission-oriented innovation policy frameworks. He emphasises that S3 by its very design has a high degree of intentionality, centralisation, prioritisation and specialisation in specific innovation areas. Foray suggests that the S3 framework and implementation experience can provide useful insights into and design principles on how to address the challenges of mission-oriented policies in three key problem areas: establishing priorities, developing transformative activity within the framework of the established priority and appreciating the experimental nature of missions.

Regarding priority setting, he stresses the importance of getting the level of granularity right: the selection of priorities should be at the level of activities that transform sectors or establish new ones, rather than at a level of an existing sector. Furthermore, the priorities should be selected in a transparent process of interactions between the public and private sector.

To be transformative, MOIP should ensure that the complementarities between existing human capital and investments in R&D. It should be based on an integrated vision of the transformative activity including both the technological and non-technological dimension of structural change and spanning the innovation chain. The policy should develop a comprehensive policy mix appropriate to the complexity of the challenges (or missions) tackled.

Foray (2018) recognises that the experimental nature of MOIP remains the most challenging problem for policy makers. The experience of S3 is critical here with its emphasis on the Entrepreneurial Discovery Process, the ambition to foster learning and knowledge spill-overs from the process and the importance of keeping the strategy flexible and responsive to new evidence.

Regional dimension of RRI

The EC also had an ambition to promote RRI among regional and local actors. The specific focus on regions was introduced only recently in the Horizon 2020 Work Programme 2018-2020 (EC, 2020). The projects fundamentally focus on S3 and, in particular, on updating S3 based on a broader input and engagement by society. The ambition is to

establish self-sustaining R&I ecosystems, characterised by a high degree of openness and responsiveness to local needs.

Exploring RRI at regional level is a young research field. Based on a systematic literature review of RRI studies, Thapa et al. (2019) found that none have focused on the regional dimension. The studies are primarily based on the debate around sensitive technology innovation such as nanotechnology, biotech and digitalisation and in and around negative consequences associated with these innovations for the society and the environment. The keyword search conducted for this review identified only one document connecting RRI with regions: Panciroli et al. (2020) propose a methodology and pilot it in three regions to map the inclusion of RRI dimensions into regional development policies and spatial planning instruments.

Expert consultations pointed to several other recent papers (Fitjar et al., 2019; Uyarra et al., 2019; Thapa et al., 2019). Most fittingly for this review, Fitjar et al. (2019) propose a conceptual integration of RRI and S3. They argue that, despite epistemological differences, S3 and RRI can be brought together into an integrated framework better suited to respond to societal challenges and foster sustainable and inclusive growth (see ***Table 9***).

RRI offers an ethical dimension of innovation to S3, where S3 can bring geography to RRI. Fitjar et al. (2019) suggest that embedding core RRI perspectives in S3 can help to incorporate social dimension across the S3 process and avoid a 'simplistic' economic approach to competitiveness.

In a similar vein, Thapa et al. (2019) suggest that RRI approaches could help to align the competing goals of achieving competitiveness and economic growth while fostering sustainability transitions. Foresight methods, for example, could help to map and anticipate the risks and opportunities of alternative transition pathways. Reflexive action research, using a participatory method such as social living labs, could support the bottom-up inclusion of new stakeholders and, thus, ensure greater plurality of voices and diversity of knowledge in the EDP. Furthermore, embedding RRI in regional innovation policies could help to identify and address differences in views and potential conflicts between stakeholders (Thapa et al., 2019), thus offering concrete tools to anticipate and tackle the risk of capture.

Insights for Smart Specialisation

Research on challenge-oriented innovation policy offers many insights into S3. The key messages for S3 are about directionality and the ambition of policy, governance, policy mix for sustainability transitions and policy learning and experimentation.

Directionality and ambition of S3

To address societal challenges and the SDGs, innovation policy at all levels should be guided by a strong strategic orientation towards sustainability. The reviewed approaches to challenge-oriented innovation policy also share the understanding that predominantly focusing on technological innovation will not be sufficient to foster and guide transformative change in a desired direction. In order to address the root problems underpinning the SDGs, S3 should adopt a broader view on system change (see e.g. Diercks et al., 2019).

Embracing a strong sustainability orientation has direct implications for the vision and priority setting in S3. Visioning and scenarios need to be extended to consider wider social and environmental trends affecting the region but also need to include an assessment of the opportunities and risks of different types of innovation in tackling social and environmental challenges. The S3 priority setting process should help to situate the SDGs and translate them into the local context. It is important, however, that priority setting is not considered a top-down process. In order to ensure shared ownership of the goals, the S3 priorities need to be the result of the blend of top-down directionality and bottom-up deliberation. The top-down direction comes with a broader political strategy and should be based on an international scientific consensus. The bottom-up deliberation is crucial to situate these priorities in the local context. They need to be based on the shared understanding of challenges and should, ideally, create

TABLE 9 *Integration of RRI into the S3 process*

	Analysis	Governance	Vision	Prioritisation	Policy mix	Monitoring
Anticipation	Identify societal needs	Identify all potential stakeholders	Consider potential negative or unintended outcomes	Consider the impact of priorities on social and environmental outcomes	Consider unintended outcomes of the policy	Evaluate more extensive effects beyond narrow policy aims
Reflexivity	Reflect on value system on which analysis is based	Consider potentially diverging interests and reflect on differences in power	Allow for different perspectives on the vision for the future	Reflect on the impact beyond the represented stakeholders – and beyond the region	Reflect on diverging interests for different policy mixes	Reflect on the value system of evaluators
Inclusion	Engage stakeholders in analysis	Include a variety of stakeholders in management	Include a variety of visions and opinions	Have an open process around prioritisation where different voices are heard	Keep policy-making democratic	Include stakeholders in the evaluation
Responsiveness	Respond to new knowledge and other perspectives	Respect all opinions, including from minority and less powerful groups	Be responsive to critical concerns about the vision	Allow for criticism of prioritisation and accept that chosen priorities may be wrong	Let dissenting voices be heard	Allow for a change in evaluation criteria and results in response to feedback

Source: Fitjar et al. (2019)

an alignment between key stakeholders. It is not a simple 'transfer of objectives' but an intermediation process.

Aligning the S3 priorities with the ambitious social and environmental sustainability goals may be challenging as it is likely to create tensions between the existing objectives of most S3 focused on competitiveness and economic development. Insights from TIP and RRI suggest that the conventional understanding of competitive advantage will often be at odds with the SDGs. RRI approaches can be helpful to identify and debate conflicting goals and deliberate ways to align them.

Governance of transformative change

TIP insists on the importance of the inclusive governance of innovation policy which actively engaged diverse stakeholders. The governance of transformative innovation policy (TIP) and mission-oriented innovation policy (MOIP) hinges on the active engagement of a variety of stakeholders. This is in line with the S3 framework; however, the S3 focused on the SDGs needs to foster a more inclusive governance approach giving a stronger voice to civil society and citizens. To better address the societal and environmental challenges and situate possible solutions in their specific context, the EDP should include challenge-led collaboration. S3 could promote and nurture environments enabling social learning focused on achieving the SDGs (e.g. networks, communities of practice).

Given the global, interconnected and complex nature of the challenges underpinning the SDGs,

scholars recognise the need to view challenge-led innovation policy and governance as a multi-scalar framework based on the collaboration between regional, national, supranational and international actors. While the higher levels of governance have a role in agreeing on the universally shared global goals and facilitating new collaborations to address global challenges, regional innovation policy is crucial for situating the global goals in the local context and fostering a variety of place-based local (and trans-local) collaborative solutions. The regional level of innovation policy is key to ensuring that the goals, while being ambitious, reflect the regional needs, research and innovation potential and capacities. The S3 model is particularly relevant here as it is a framework mobilising multi-stakeholder collaboration with a transformative ambition.

Policy mix for sustainability transitions

Another implication of embedding a strong sustainability-oriented directionality into innovation policy means that it should be reflected in policy mixes. There is growing research on policy mixes for sustainability transitions, although their focus at regional level is still limited. The general insights from this research are relevant and applicable to the regional level, even if the institutional capacity may be not as developed and the availability of policy options and instruments may not be as comprehensive as at national level. The approaches to a policy mix in S3 may benefit from research on innovation policy mixes and policy mixes for sustainability transitions specifically.

On the one hand, policy makers responsible for S3 should consider the general principles of a good design of policy mixes ensuring the consistency of goals, adjusting the comprehensiveness of the mix to the challenges addressed and striving for better horizontal and vertical policy coherence. Policy roadmaps can be useful instruments to improve coordination and coherence over time. On the other hand, there is a need for policy and governance experimentation to try out new instruments and governance arrangements which can directly support more ambitious innovation niches in the selected S3 priority areas. Policy makers can, for example, innovate the designs of specific instruments to stimulate demand for sustainable innovation (e.g. public procurement) as well as experiment with new regional and local rules to promote sustainable practices (e.g. promoting sustainable mobility).

Policy learning and experimentation

The evidence base of innovation policies for the SDGs need to be adjusted to support the proper design and implementation of a policy and their monitoring and evaluation systems revisited to ensure continuous learning and embrace complexity and uncertainties linked to transformative change. On the one hand, there is a need to include new dedicated metrics and indicators which allow the relevant social and environmental outcomes and impacts of S3 to be measured, including its unintended effects inside or outside of the region. These new indicators are key to tracking the progress towards achieving the regional sustainability goals, as well as measuring the regional contribution to the SDGs.

On the other hand, there is a need to redesign the M&E (monitoring and evaluation) system to become a continuous reflexive process of policy learning, engaging various stakeholders in a debate on whether and to what extent the S3 priorities and effects respond to the short- and long-term challenges of the region. It is key that the new evidence and feedback from stakeholders lead to the adaptation of S3. The M&E system should be co-designed with key departments within the regional, national or local authority as well as key S3 stakeholders. This is key to ensuring its credibility and usefulness during the implementation.

Table 10 summarises relevant insights and useful concepts and tools from the challenge-led innovation policy for the sustainability-oriented S3. The table also points out several limitations to and challenges for using these insights in policy and planning practice.

TABLE 10 *Advantages and limitations of the challenge-led innovation policy perspective on embedding the SDGs in S3*

S3 ELEMENTS	INSIGHTS, CONCEPTS AND TOOLS RELEVANT FOR S3	CHALLENGES AND LIMITATIONS OF THE PERSPECTIVE
GOVERNANCE Setting out the RIS3 process and governance	Inclusive approach to governance, ensuring the participation of civil society and citizens Link the EDP to sustainability goals and concrete local challenges Facilitate challenge-led collaboration and build an environment enabling social learning focused on achieving the SDGs (e.g. networks, communities of practice)	Broadening participation in the design and implementation of S3 requires changes to the established approaches to identify and select stakeholders The involvement of new stakeholders, especially vulnerable groups and groups at risk, increases the diversity of worldviews and may lead to new disagreements or even conflicts
DIAGNOSIS Analysing the innovation potential	Be open to new theoretical and conceptual frameworks to adopt a systems approach to sustainability transitions Use foresight to anticipate and reflect on emerging trends, including new user needs and preferences relevant to the sustainability goals Be reflexive about worldviews and normative perspectives underpinning the diagnosis	Broadening and deepening the diagnosis requires investment in the regional institutional capacity, and broadening expert and research communities involved in S3
VISION Developing a shared vision and scenarios	Develop a shared vision addressing societal challenges and localising the SDGs in a regional context Open the visioning and scenario process up to different perspectives and critical views Consider a variety of future scenarios and be open to criticism Reflect on and assess the possible negative (internal and external) effects of different scenarios	This may require investment in building an in-house foresight capacity to ensure that foresight exercises are embedded in and inform the S3 process
PRIORITIES Identifying the priorities	Align the S3 priorities with social and environmental challenges, and the SDGs Add the strategic orientation towards the SDGs to the S3 priorities as well as embedding it throughout the innovation policy mix	Challenging process to identify and scope actionable goals (e.g. differences between mission-oriented approaches and broader transformative innovation policy)

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>TABLE 10

S3 ELEMENTS	INSIGHTS, CONCEPTS AND TOOLS RELEVANT FOR S3	CHALLENGES AND LIMITATIONS OF THE PERSPECTIVE
ACTION PLAN Defining an action plan with a coherent policy mix	Embed directionality and transformative ambition in the regional policy mix Reflect on how to ensure horizontal coordination between key regional policies and how to align with the national and EU policies Use a variety of instruments to support transitions: make sure to use demand-side policy instruments (e.g. innovation procurement) to create a local demand for sustainable innovation Support portfolios of projects aligned with the nature and dynamics of transition pathways in the selected S3 priority areas Develop dedicated spaces to encourage the co-design and experimentation of system innovation, including governance and policy experimentation Critically consider the interests and preferences of stakeholders in different policy options	The policy mix approach requires new institutional capacities and, in some instances, new or re-organised competences in the region Ensuring directionality through horizontal coherence (across policies and departments in the region) can pose a significant organisational challenge, especially for regions with limited horizontal coordination mechanisms Addressing vertical coherence can be particularly challenging as it requires establishing inter-organisational coordination processes
POLICY LEARNING Monitoring and evaluating	Include metrics and an evaluative reflection on the wider environmental and social outcomes of S3 in the monitoring and evaluation (M&E) system, including its unintended effects Include experts and stakeholders in the M&E process and in the broader reflection on S3 results Ensure that the M&E system can be changed in response to new evidence and feedback	Adjusting the monitoring and evaluation requires investment in the regional evaluation capacity

2.3. Key insights into Smart Specialisation from the literature review

SHARED DIRECTION TOWARDS THE SDGS – NORMATIVE AND CONCEPTUAL IMPLICATIONS OF DIRECTIONALITY

Smart Specialisation strategies are directional by design and, as a concept and strategic framework, may be considered well suited to join a family of challenge-oriented innovation policies (Foray, 2018; Matusiak et al., 2020). One fundamental challenge in aligning S3 with the SDGs is, however, normative. It is about reorientating the purpose of S3 from the logic of regional competitive advantage to the logic of sustainable development. While there is clearly some space for a 'win-win' between the two orientations, the optimistic green growth logic has limits, especially if S3 is to foster transformative change. The reorientation will inevitably accentuate tensions and trade-offs between economic, social and environmental objectives.

The current focus of S3 is too narrow to address societal and environmental goals, such as the SDGs, in a systemic way. Fostering sustainability transitions will, therefore, require broadening the

scope of S3 and a redefinition of 'territorial competitiveness', which will have significant implications for all aspects of S3 if taken onboard fully. To embrace the new normative orientation, the S3 framework will need to be open to new theoretical and conceptual insights from various research traditions which have assumed a broader understanding of a system and a system change. The three perspectives introduced in the preceding sections are among such systemic research perspectives.

On a positive note, there is a degree of convergence between the S3 framework and these sustainability-oriented perspectives, partly because they share their interest in structural change and have their roots in evolutionary systems thinking. There are many relevant elements in the current S3 framework which make it possible to adapt it rather than scrap it and start anew. Yet they also differ in significant ways.

Firstly, there are differences regarding the underlying rationale of change. To put it in simple terms, whereas sociotechnical transition and social-ecological perspective focus on sustainable development, S3 has a core focus on economic goals, notably on constructing competitive economic advantage. There is a normative divergence between different S3 and other reviewed approaches. The normative aspect of aligning S3 with the SDGs needs to be openly discussed and recognised as a key element of the strategy and the process. As demonstrated, it has concrete implications for all S3 elements and processes.

Secondly, there are conceptual differences in how they approach systemic change. With its theoretical roots in evolutionary economics, innovation systems and the new thinking on industrial policy (Foray et al., 2009), S3 views the process of structural change from an economic perspective. Even if Foray and colleagues (2012) explicitly mention the need to address societal challenges and to engage in new types of innovation, the predominant focus remains on structural economic change and industrial transition. Little attention is given to changing social practices and consumption systems or to the wider environmental and social implications of strategic choices made[2]. While S3 mainly focuses on economic change, the three reviewed perspectives draw broader system boundaries and focus on the co-evolution between society and technology (sociotechnical system) and between society and the environment (social-ecological systems). They are, therefore, useful to draw upon.

Scholars and analysts emphasise that the actual strategic direction of a policy is shaped by the specific political and institutional contexts in which their objectives are interpreted, localised and implemented. Even with the strong push from the EGD, the directionality failure of innovation policy will have to be addressed to a significant degree at national but also regional, urban and local level. There is an opportunity for S3 to become a key strategic framework to give S3 a stronger sustainability orientation aligned with the EGD and the SDGs on the ground. To do so, the new S3 framework needs to embrace a broader understanding of system change and refocus on sustainability transitions.

Whole-system transformation towards sustainability – From industrial transition to system transformation

Structural change and industrial transformation have been at the core of S3 (Foray et al., 2009; Foray et al., 2012) but, as mentioned above, its conceptual framework fails to offer a deeper elaboration of wider system changes which embrace social and environmental dimensions. The conceptualisation of system change is where the S3 framework lacks the sophistication to address many of the root problems underpinning the SDGs. S3, however, can extend its boundaries and build on the perspectives and concepts developed in sociotechnical transitions and social-ecological resilience research. The sustainability-oriented S3 framework can integrate the concepts of a socio-

2 *The risks of paying insufficient attention to social impacts of economic policies have been elaborately discussed in literature (Rodríguez-Pose, 2018).*

technical system and social-ecological system and a co-evolutionary approach to system change. This broader view on transformation has implications for all elements of S3, from governance and the Entrepreneurial Discovery Process to the approach to monitoring and evaluation.

Research on the mechanisms and dynamics of transition pathways from the sociotechnical transition perspective is of particular relevance to S3. A more systemic reflection on the advantages and disadvantages of pursuing alternative transition pathways is essential for identifying and prioritising innovation areas and governance arrangements most relevant to sustainability goals a region envisages to pursue.

Insights from social resilience literature confirm the importance of participatory processes in identifying and developing a shared understanding to localise societal challenges. The impacts of societal challenges, such as climate change, are not the same for all regions. The understanding of impacts differs between different stakeholders; it is key that the S3 processes, including the EDP, recognise and address these differences.

System innovation is a highly ambitious and difficult goal to pursue. It involves a great deal of risk and uncertainty and cannot be controlled in a top-down manner. The S3 model has good foundations to address such complex processes with its blend of top-down directionality and bottom-up processes of 'self-discovery' and experimentation. A sociotechnical perspective and resilience research support the role of experimentation but they also call for a diversity of innovation niches to foster the processes of transformative change. Opening up to a greater variety of innovations is likely to support regional resilience as the region can be better prepared to respond to societal challenges, especially if its impacts are uncertain. But it can also place the region in a good position to benefit from emerging, yet uncertain, opportunities.

Fostering transformative change requires a more systemic approach to policy. Policy mix research offers rich and practical insights into how to (and how not to) design and implement innovation policies aiming to foster sustainability transitions. Firstly, policy makers responsible for S3 should consider the general principles of a good policy design – such as ensuring the consistency of goals, adjusting the comprehensiveness of the mix to the challenges addressed and striving for better horizontal and vertical policy coherence. Policy roadmaps can be useful instruments to improve coordination and coherence over time.

Secondly, there is a need to try out new instruments and instrument designs and governance arrangements which can directly support more ambitious innovation niches in the selected S3 priority areas. Policy makers can, for example, innovate designs of specific instruments to stimulate demand for sustainable innovation (e.g. public procurement) as well as experiment with new regional and local rules to promote more sustainable practices (e.g. promoting innovative mobility solutions). In order to be transformative and not end up as isolated single experiments, experimentation should be embedded in policy mixes, and linked to the monitoring and evaluation process to ensure lessons learned from successful and unsuccessful exercises are considered in policy decisions.

Reflexivity and responsibility – S3 as a social learning exercise

The shift from striving for regional competitive advantage to considering the wider sustainability impacts of S3 is a major change for the entire process. The priority setting process, for example, will become more heterogeneous and is bound to stumble upon new dilemmas and trade-offs. Regions will need to extend their sense of responsibility for their innovation choices not only towards their own citizens but also towards people and ecosystems that may be impacted by these decisions outside of the region. Shifting the focus to more transformational priorities requires a broader social mandate for S3.

To anticipate and tackle these challenges, the S3 framework will need to include a stronger emphasis on social learning and reflexivity throughout the S3 process. At strategic level, S3 should engage

various stakeholders in a continuous policy debate – from developing a shared vision and transition pathways to discussing evidence on whether and to what extent S3 contributes to sustainability transition in the region. It is key that the new evidence and feedback from stakeholders lead to revisions of S3. At operational level, S3 should build an environment enabling inclusive social learning, notably by supporting niche experimentation focused on specific sustainability challenges. S3 governance should ensure that these two levels are closely interconnected: the strategic level is a space for deliberating and localising sustainability goals, while the operational level is a space for the EDP, co-creation and experimentation. It is essential that lessons from experiments are reflected in policy learning.

All three perspectives offer useful concrete insights into the above. A social-ecological resilience perspective offers rich case studies on social learning and social innovation, emphasising the importance of inclusivity and local knowledge. Sociotechnical transition scholars developed policy frameworks which embed reflexivity (e.g. TM) and have contributed to growing literature on the role of experimentation which emphasise the importance of governance and policy experiments. Challenge-led innovation policy approaches all stress the importance of policy evaluation. RRI is particularly relevant as it offers an integrated framework and tools designed for a deeper reflection on innovation which can help to identify, mediate and align competing goals.

Table 11 summarises insights from the three reviewed perspectives which can help to address the limitations in the current S3 model and provide building blocks for the sustainability-oriented S3 framework.

TABLE 11 *Key insights from the reviewed theoretical perspectives on embedding the SDGs in S3*

S3 ELEMENTS	KEY LIMITATIONS OF THE S3 MODEL	INSIGHTS FROM SOCIOTECHNICAL TRANSITIONS	INSIGHTS FROM SOCIAL-ECOLOGICAL RESILIENCE	INSIGHTS FROM CHALLENGE-LED INNOVATION POLICY
GOVERNANCE Setting out the RIS3 process and governance	Limited focus on ensuring the shared ownership of priorities and inclusion of marginalised groups or groups at risk of being impacted by new environmental, social or technological trends Limited focus on creating an environment for more inclusive and/or problem-based or mission-oriented learning addressing sustainability challenges Bottom-up processes mainly limited to searching for solutions to top-down priorities The lack of coordination mechanisms between regions and between regions and other levels in addressing sustainability challenges in a collaborative way	Include MLP in stakeholder mapping Reflect on the roles, interests and expectations of incumbent and new niche actors in S3 governance (e.g. to anticipate and manage conflicts and capture)	Ensure inclusivity of the process, in particular to include previously excluded groups (e.g. marginalised groups and groups at risk)	Inclusive approach to governance, ensuring the participation of civil society and citizens Link the EDP to sustainability goals and concrete local challenges Facilitate challenge-led collaboration and build an environment enabling social learning focused on achieving the SDGs (e.g. networks, communities of practice)
DIAGNOSIS Analysing the innovation potential	Limited consideration of a wider socio-economic and socio-ecological system and limited focus on analysing regional impacts of global challenges Limited focus on the positioning of a region in international value chains relevant to fostering sustainable innovation Limited focus on sustainability transitions and local and global drivers and barriers of systemic transformation	Concepts of sociotechnical systems and transition pathways Analyse the potential role of regional research and innovation actors in fostering the sustainability transition of key sociotechnical systems in your region (and beyond) Analyse profiles and interactions between regional incumbent and niche actors in sociotechnical systems addressed by S3 (e.g. are they focused on the SDGs?) Consider a long-time horizon in analysing sociotechnical transition Analyse the positioning of the region in global value chains	Concepts of social-ecological systems, transformational resilience and a co-evolutionary approach to system change Include a longer-view perspective on the social-ecological system and the positioning of the region in the global eco-system Manage expectations between the scale of change possible to be achieved in the long and shorter term Analyse the role of research and innovation to address societal challenges while ensuring transformational resilience Critical perspectives to better understand the frameworks and motivation of local actors, and how they interpret scientific evidence	Be open to new theoretical and conceptual frameworks to adopt a systems approach to sustainability transitions Use foresight to anticipate and reflect on emerging trends, including new user needs and preferences relevant to the sustainability goals Be reflexive about worldviews and normative perspectives underpinning the diagnosis
VISION Developing a shared vision and scenarios	Limited emphasis on ongoing foresight allowing the debate on vision and scenarios to be nurtured Limited variety and narrow conceptualisation of transition pathways predominantly focused on industrial change rather than sustainability transitions Limited view on the role of inter-local and interregional collaboration in addressing societal challenges and the SDGs	Concept of transition pathways (actors and interaction, temporal dynamics, systemic barriers and drivers) Use the concept of transition pathways in deliberating vision and scenarios (e.g. regime and niche actors, interactions and mechanisms, rules and institutions)	Broaden the regional vision to include a social-ecological perspective (e.g. navigating complexity and placing technological change in the wider social-ecological perspective) The transformative resilience perspective can be used in scenario development (e.g. resilience of transition pathways)	Develop a shared vision addressing societal challenges and localising the SDGs in the regional context Open the visioning and scenario process up to different perspectives and critical views Consider a variety of future scenarios and be open to criticism Reflect on and assess the possible negative (internal and external) effects of different scenarios

> TABLE 11

S3 ELEMENTS	KEY LIMITATIONS OF THE S3 MODEL	INSIGHTS FROM SOCIOTECHNICAL TRANSITIONS	INSIGHTS FROM SOCIAL-ECOLOGICAL RESILIENCE	INSIGHTS FROM CHALLENGE-LED INNOVATION POLICY
PRIORITIES Identifying the priorities	Lack of explicit focus on sustainability goals and localising the SDGs Limited consideration of the limits to a competitiveness-driven approach to address many sustainability challenges; limited focus on how to exploit regional potential to respond to global challenges and the SDGs Limited focus on localising the SDGs and ensuring shared ownership of goals locally	Find a balance between prioritising niche innovations and the modernisation of established specialisation areas Situate the SDGs in the local context Adjust priorities to the regional and global dynamics of transition pathways in the S3 areas	Engage local actors to develop shared ownership of strategies and to localise the SDGs	Align the S3 priorities with social and environmental challenges, and the SDGs Add the strategic orientation towards the SDGs into the S3 priorities as well as embedding it throughout the innovation policy mix
ACTION PLAN Defining an action plan with a coherent policy mix	Little focus on the implications of sustainability-orientation directionality for selecting and designing instruments The lack of a conceptual framework for a challenge-led roadmapping exercise addressing sustainability goals Limited emphasis on system innovation and integrated experimentation focused on a system change	Ensure directionality and policy coordination Develop dedicated spaces to encourage the co-design and experimentation of system innovation, including governance and policy experimentation (positive and negative lessons from applying the Transition Management and SNM approaches) Importance of supporting internationalisation for niche development and experimentation by connecting with emerging or mature innovation activities in other regions) Emerging research on policy mixes for sustainability transitions (see insights from research on transformative innovation policy)	Support inclusive local experimentation focused on social innovation	Embed directionality in the regional policy mix Reflect on how to ensure horizontal coordination between key regional policies and how to align with the national and EU policies Use a variety of instruments to support transitions, notably demand-side instruments to create local demand for sustainable innovation Support portfolios of projects aligned with the nature and dynamics of transition pathways in the S3 areas Develop dedicated spaces to encourage the co-design and experimentation of system innovation (including policy experimentation) Consider the interests and preferences of stakeholders in different policy options
POLICY LEARNING Monitoring and evaluating	No explicit focus on assessing the social and environmental impact of transition and on monitoring progress towards the SDGs Limited focus on reflexivity and policy learning	Need for formative and pluralistic approaches to the monitoring and valuation of transition pathways in S3 Empirical-based lessons learned on designing experiments to enhance social and policy learning	Emphasis on embracing complexity and the uncertainty of transformations Insights into processes and mechanisms of social learning Insights into the importance of including and appreciating the role of local knowledge and expertise in the design and implementation of projects	Include metrics and an evaluative reflection on the wider environmental and social outcomes of S3 in the monitoring and evaluation (M&E) system, including its unintended effects Include experts and stakeholders in the M&E process and in the broader reflection on S3 results Ensure that the M&E system can be changed in response to new evidence and feedback

3. Towards a framework of Smart Specialisation for the SDGs

3.1. Guiding principles

The original guide to Smart Specialisation strategies (Foray et al., 2012) proposed four principles to guide the design and process of S3:

- *choices and critical mass.* S3 should be based on a limited number of priorities selected on the basis of country's and region's own strengths and international specialisation which is to avoid duplication and fragmentation in the European Research Area and help concentrate funding sources, ensuring more effective budgetary management;
- *competitive advantage.* S3 should mobilise talent by matching research and innovation capacities and business needs through an Entrepreneurial Discovery Process;
- *connectivity and clusters.* S3 should develop world-class clusters and provide arenas for related variety and cross-sector links, internally in the region and externally, which drive specialised technological diversification;
- *collaborative leadership.* S3 should support efficient innovation systems as a collective endeavour based on public-private partnership (quadruple helix) and provide an experimental platform to give a voice to unusual suspects.

The original principles have not lost their pertinence, and they can be usefully applied to support the SDGs. In order to harness the regional potential for address sustainability challenges more effectively, however, they need to be guided by a stronger strategic orientation and moral compass pointing towards a shared vision of a sustainable Europe in a sustainable world. S3 needs to find its role in a broader transition effort brought together by the recognition of the need to address global environmental and social challenges.

To recognise this challenge, we propose adding three overarching guiding principles to give S3 a stronger sense of direction and transformative ambition.

- *Shared direction towards the SDGs.* S3 should be guided by the SDGs as an overarching direction of transition. SDGs should become a foundational reference for the regional vision and a guide for identifying and selecting key priorities at different territorial levels; the role of the following S3 process will then be to mobilise science, technology and broadly understood innovation to address these challenges.
- *Whole-system transformation towards sustainability.* S3 should extend its focus on structural change to reflect and foster wider sociotechnical and social-ecological transitions

needed to tackle sustainability challenges. The S3 process should aim to clearly identify specific areas and niches where the community of stakeholders can meaningfully act and achieve measurable change while contributing to wider systemic transformations.

- *Responsibility and reflexivity.* S3 should explicitly integrate a moral and ethical compass needed to navigate difficult transition choices which balance capturing value for the region with contributing to tackling global environmental and social challenges. A policy learning capacity is needed to identify and foster synergies and to openly discuss trade-offs and limitations. This is key to harnessing the potential of S3 to work towards 'just transitions' that leave no one behind and create value for future generations.

These overarching principles have implications for the original four dimensions (see ***Table 12***). In most cases, they can be usefully aligned – e.g. the Entrepreneurial Discovery Process and experimentations can be highly valuable for co-designing innovation activities fostering niches where transformative innovations are co-created and tested. But they may have more significant implications for the notion of competitive advantage. Seeking differentiation from other regions will remain key to regional planning and strategies; however, accepting the SDGs as a framework implies a deeper reflection on the motivations and rules guiding regional and interregional competition.

3.2. Embedding the SDGs in the components of S3

This section provides practical recommendations on how to develop research and innovation strategies for Smart Specialisation to contribute to the SDGs. The framework builds on the theoretical and conceptual insights and empirical findings from the literature review.

The guidance is structured around six key elements of S3 as laid out in Foray et al. (2012):

- diagnosis – analysing the innovation potential;
- governance – setting out the RIS3 process and governance;
- vision – developing a shared vision and scenarios;
- priorities – identifying the priorities;
- action plan – defining an action plan with a coherent policy mix;
- policy learning – monitoring and evaluating.

The guidance is prepared to inform both the new S3 strategies as well as to ensure the continuity and renewal of existing strategies. ***Table 13*** outlines the key elements of the framework.

Annex I proposes a tentative questionnaire for ongoing self-evaluation and reflection on embedding the SDGs in S3.

TABLE 12 *Implications of integrating the SDGs for the four principles of S3*

S3 PRINCIPLES	SHARED DIRECTION TOWARDS THE SDGS	WHOLE-SYSTEM TRANSFORMATION	RESPONSIBILITY AND REFLEXIVITY
CHOICES AND CRITICAL MASS	The choice of S3 priority areas to consider societal challenges and how to localise the SDGs. The priorities to build and harness the 'critical mass' of the regional research and innovation potential and interregional and international partnerships to address the sustainability challenges and the SDGs.	Focus on innovations with a potential to foster systemic transformation of the region towards more sustainable modes of production and consumption. 'Critical mass' needs to be conceptualised in the context of building innovation potential to foster transitions of key regional systems (e.g. energy, mobility, food). Depending on the challenge, 'critical mass' for transition may imply scaling existing solutions or developing a variety of experimental projects. The choice of strategic challenges will become the new prioritisation process, and the action plans for specific priorities should be deep dives into specific challenges and the best ways to address them.	The choices of priority areas and transition pathways to be underpinned by an assessment of their economic, social and environmental impacts and value created inside and outside the region. Reflection on how to ensure that transitions away from established unsustainable systems and practices do not lead to lasting exclusion and marginalisation ('just transitions').
COMPETITIVE ADVANTAGE	Need to redefine competitiveness, ensuring that developing a sustainable competitive economic advantage does not come at external costs – or does not create future pressures – for the society and environment inside and outside the region, in Europe and globally. Stronger focus on collaboration, including experimentation projects, with other regions facing similar societal challenges.	Focus on developing systemic foundations for future regional resilience.	Reflection on the potential implications of strategic choices driven by building competitive advantages of the region for social groups and a natural environment in regions potentially adversely affected by these decisions (e.g. choice of suppliers or buyers).
CONNECTIVITY AND CLUSTERS	Providing incentives for partnerships, clusters and networks to develop a shared vision and alignment towards the SDGs.	Developing and supporting challenge-oriented or mission-oriented partnerships, clusters and networks engaged in emerging niches or promising demonstrations of transformative innovation addressing sustainability goals.	Ensuring the new challenge-oriented or mission-oriented cross-sectoral partnerships, clusters and networks include relevant stakeholders and are not captured by incumbents.
COLLABORATIVE LEADERSHIP	Ensuring that leaders of the process subscribe to and embrace the sustainability orientation and the SDGs.	Experimenting with new forms of collaborative leadership and forms of governance suitable for orchestrating long-lasting multi-actor and multi-level processes of change.	Ensuring that decisions taken on priorities and transition pathways as well as the forms of leadership and governance of transitions have a broad social mandate.

TABLE 13 *Embedding the SDGs in the main components of S3*

S3 components	Current focus	Additional actions to embed the SDGs in S3
Governance Setting out the S3 process and governance	Broad and comprehensive stakeholder participation in the S3 design, including firms and entrepreneurs, research and academia, public sector as well as innovation users or groups representing consumers and NGOs representing citizens and workers. ■ Inclusive governance to prevent capture by specific interest groups, powerful lobbies or major regional stakeholders. ■ Governance to allow for 'collaborative leadership' and shared ownership of the process. ■ 'Boundary spanners' to foster collaboration and manage potential conflicts.	With its inclusive approach, the existing model of S3 is generally well-suited to addressing sustainability challenges. The S3 for the SDGs governance needs: ■ more emphasis on encouraging the participation of actors and institutions whose missions align with the SDGs and who can translate SDGs into concrete local (or trans-local) challenges, and those who are at risk of being impacted by societal challenges. Ensuring broader inclusion is key to preventing the risk of capture; ■ an EDP to incorporate a challenge-led or mission-oriented dimension that harnesses bottom-up experimentation for a concrete purpose; ■ a stronger emphasis on ensuring the continuity and strengthening the learning dimension of the EDP. The latter could become a transformational process supporting social and organisational learning (double-loop learning) addressing challenges.
Diagnosis Analysing the innovation potential	A comprehensive and sound analysis of the regional economy, society and innovation structure, aiming at assessing both existing assets and prospects for future development. Three dimensions of diagnosis: ■ regional assets, such as technological infrastructures, ■ linkages with the rest of the world and the position of the region within the European and global economy, and ■ dynamics of the entrepreneurial environment.	The diagnosis should be complimented by a comprehensive analysis of regional and local drivers and impacts of global environmental and societal challenges underpinning the SDGs. The diagnosis should include the following: ■ current and potential future impacts and risks associated with global environmental and societal challenges for the regional economy, society and natural environment; ■ the innovation potential of regional actors, institutions and infrastructure to adapt and innovate to address challenges, and the SDGs; ■ the diagnosis should reflect scientific knowledge, diverse local expertise and stakeholder perspectives on the challenges and the SDGs, including views held by groups directly at risk.

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> TABLE 13

S3 COMPONENTS	CURRENT FOCUS	ADDITIONAL ACTIONS TO EMBED THE SDGS IN S3
VISION Developing a shared vision and scenarios	The scenario constitutes the basis for developing a vision about where the region would like to be in the future, what the main goals to achieve are and why they are important. ■ Having a clear and shared vision of regional development is crucial in order to keep stakeholders engaged in the process. ■ Both during the RIS3 design process and throughout the process of implementation of the strategy, it is crucial to have good communication, which is key for generating positive tension in the regional society around strategic goals, maintaining stakeholder engagement and encouraging new stakeholders to join.	The overall regional vision should be based on the systemic reflection on the impacts and risks as well as new opportunities stemming from societal challenges and the SDGs. The vision of regional transition should be elaborated further by: ■ adding a strong focus on sustainability transition and an overarching orientation towards the SDGs; ■ a visioning process and scenarios of change developed for each specialisation (priority domain) in the region. This could generate more active engagement of stakeholders in the process and become part of a challenge-led EDP; ■ scenarios to deliberate and discuss alternative transition pathways and a variety of innovation approaches to respond to challenges. Scenarios should discuss the uncertainties and risks faced by the region and reflect on wider societal and environmental impacts of different pathways.
PRIORITIES Identifying the priorities	Priority setting in the context of RIS3 entails an effective match between a top-down process of identification of broad objectives aligned with EU policies and a bottom-up process of emergence of candidate niches for Smart Specialisation, areas of experimentation and future development stemming from the discovery activity of entrepreneurial actors. It is of crucial importance that RIS3 governance bodies focus on a limited number of innovation and research priorities in line with the potential for Smart Specialisation detected in the analysis phase that is anchored in entrepreneurial discoveries. These priorities will be the areas where a region can realistically hope to excel.	Priorities should ensure that S3 mobilises regional research and innovation potential to foster transformative change responding to key sustainability challenges. ■ Priorities should identify key objectives and transition pathways selected to foster sustainability transitions in the region. ■ The original logic of balancing a top-down identification with bottom-up entrepreneurial discovery is relevant; however, the bottom-up processes of social learning are crucial for localising or situating broad objectives, including the SDGs, in the local context. The latter is key to ensuring the priorities are shared and owned by regional stakeholders. ■ The logic of concentration to develop 'critical mass' to address challenges is also relevant but it needs to be nuanced considering the need to ensure variety to build regional resilience. Critical mass can be also achieved through partnerships and interregional and international cooperation.

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> TABLE 13

S3 components	Current focus	Additional actions to embed the SDGs in S3
Policy roadmap Defining an action plan with a coherent policy mix	Roadmap with an action plan allowing for a degree of experimentation through pilot projects. An action plan is a way of detailing and organising all of the rules and tools a region needs in order to reach the prioritised goals, and it should provide for comprehensive and consistent information about strategic objectives, timeframes for implementation, identification of funding sources, tentative budget allocation. Pilot projects are the main tools for policy experimentation and allow the testing of unprecedented mixes of policy measures on a small scale. They should be coupled with effective evaluation mechanisms leading to the sound appraisal of success and feasibility as mainstream RIS3 projects.	Policy roadmaps providing a strategic framework for a policy mix focused on addressing transformative challenges and the SDGs. ■ Include a comprehensive portfolio of instruments supporting different types of innovation projects adjusted to the challenge addressed. ■ Use demand-side instruments to create demand and shape niche markets for transformative innovation. ■ Support experimentation and demonstration projects fostering emerging and established innovation niches aligned with the selected transition pathways. ■ Include goals, targets and milestones allowing for tracking progress in achieving sustainability objectives. ■ Be flexible to allow the roadmap to be adjusted based on monitoring and evaluation and on the EDP.
Policy learning Monitoring and evaluation	Mechanisms for monitoring and evaluation to be integrated into the strategy and its different components from the beginning. A strategy should evolve and adjust to changes in economic and framework conditions, as well as to the emergence of new evidence during implementation through evaluation and monitoring activities. Peer reviews as a key instrument to improve S3.	Monitoring and evaluation should incorporate: ■ new methodologies helping to navigate complexity and analyse processes of systemic change, including understanding interlinkages between sustainability goals; ■ new indicators for monitoring and evaluation allowing the analysis of the outcomes and impacts of S3 on sustainability challenges and the SDGs; ■ stronger emphasis on formative evaluation focused on transformative change towards the SDGs; ■ learning mechanisms (e.g. community of practice) and knowledge management tools supporting the ongoing EDP.

Source: Own elaboration. The focus of the current framework is based on Foray et al. (2012).

4. Conclusions and recommendations

This paper offers a critical reflection on whether and to what extent the current theoretical and conceptual framework of S3 aligns with the direction and scale of change needed to effectively address the SDGs.

As a basis of this analysis, we reviewed existing literature on Smart Specialisation and regional innovation strategies addressing sustainable development and the SDGs. We then focused on three theoretical perspectives: sociotechnical transitions, social-ecological resilience and challenge-driven innovation policies. We examined each of these perspectives considering their theoretical underpinnings and insights for governance, strategy and policy for place-based innovation. We then discussed how these insights can support alignment between S3 and the SDGs and proposed a conceptual framework of S3 for the SDGs. There are several broad policy recommendations for Smart Specialisation stemming from this work.

An overall message is that the S3 framework should be revisited and extended if it is to foster transformative system innovation for the SDGs. S3 can be (and have been) used by regions to promote innovation which can contribute to, for example, greening industrial sectors in line with the modernisation pathway (e.g. improving material and energy efficiency). The current S3 model is, however, less suitable for promoting transformative change leading to the achievement of SDGs in the longer term.

The review yields several broad recommendations on how to align S3 with the SDGs and the transformative ambition of the Agenda 2030 embraced by the European Green Deal.

Introduce a strong directionality towards the SDGs

The S3 for the SDGs and sustainability challenges framework needs to embed a strong directionality towards the SDGs to guide design and implementation of S3 across all governance levels. The framework should encourage all regions to re-engage in the vision-building and discovery process, this time with a focus on sustainability challenges, and provide a framework for deliberation and choices of transition pathways towards high-level sustainability goals. The SDGs offer a strategic guidance for selecting areas of specialisation and inter-regional collaborations.

The framework needs to be open to allow diverse pathways and different types of innovations, but at the same time it should encourage investment in those capacities, projects and policies that support innovation with a transformative potential. The variety of pathways and bottom-up experimentation should come hand in hand with the stronger directionality; regardless of the context, S3 should have a common direction for all. To put it simply, regions should be pursuing a common set of overarching goals, but they will be moving at a different pace and using different pathways, taking into account their specific territorial needs. This calls for the localisation of SDGs/sustainability challenges to make them meaningful to local and regional communities.

Foster a whole-system transformation towards sustainability

The S3 for the SDGs should broaden its focus from industrial transition to wider sociotechnical and social-ecological transitions needed to tackle sustainability challenges. The discovery process could aim to identify specific areas and niches of sustainable innovation where the community of stakeholders can meaningfully act and achieve measurable change while contributing to systemic transformations. This can be done in two ways – by carefully considering societal and environmental impacts of innovative projects and proposals but also mobilising the entrepreneurial/community discovery process for innovation for public purpose – key societal and environmental challenges identified during the SDG localisation process.

The S3 framework refocused on the SDGs would be open to a greater variety of innovation, specialisation areas and transition pathways. This new scope aligns S3 with sustainability objectives which recognise the urgency and necessity of whole system change to address major societal challenges such as the climate crisis, demographic changes, gender issues and responsible consumption.

Nurture responsible and reflexive S3 culture

The SDGs can become a moral and ethical compass for S3 to navigate complex, and often uncertain, transition choices. There is a need to invest in governance processes to openly discuss possible synergies and trade-offs between different transition pathways. This is key to harnessing the potential of S3 to work towards 'just transitions' that leave no one behind and create value for future generations.

The S3 for the SDGs needs to include a stronger emphasis on reflexivity throughout the process. At a strategic level, S3 could engage various stakeholders in a continuous policy debate and deliberation. At an operational level, S3 could build an environment enabling inclusive social learning, notably by supporting discovery process, co-creation and experimentation focused on specific sustainability challenges. There is need to ensure that these two levels are closely interconnected, e.g. it is essential that lessons from experiments are reflected in policy.

Leave no place behind

The new framework needs to be context-dependent and adjustable to consider different challenges, innovation potential, institutional capacities, financial resources as well as political and democratic mandates of countries and regions. The revised S3 framework will need to allow all countries and regions to deliberate and choose their own pathways, less or more radical, and recognise that they are at very different points on their journeys towards sustainability, but can still contribute to the ongoing wider, European and global effort. This is crucial to ensuring that the new framework is relevant to all regions and not just for some – as Foray (2019) recently argued.

It is essential to emphasise that system innovation is not portrayed as a concept only for advanced regions. The S3 framework should explain the benefits and risks of this approach and emphasise the need to build specific institutional capacities to engage in and learn from such projects, including in the less advanced regions. As in previous years, the framework needs to be supported by dedicated platforms and interregional communities of practice where experiences can be shared, and new capacities can be built.

The proposed S3 for sustainability framework embedding the SDGs and questionnaire for self-evaluation and reflection on embedding SDGs in S3 ('S3 sustainability check') are prototypes which need further elaboration and co-creation with practitioners and experts. As mentioned above, the tools and guidance for the regions need to be further elaborated to be used by regions with different interests and commitments towards the SDGs. Depending on the initial self-assessment, the guidance may range from advice on how to promote greener goods and technologies

to suggestions on how to reorient S3 to align it with transformative approaches to sustainability transitions. The framework should come with an opportunity to discuss the advantages and challenges of different approaches with experts and regions.

Boost interregional policy learning

Policymakers involved in the preparation of new S3 strategies should draw lessons from the implementation and evaluation phases of the first generation of S3 strategies and on experience from other EU regions and countries (Ciampi Stancova, 2020). Policy learning is the vehicle to achieve innovation-related goals that are in line with sustainability objectives, such as greater competitiveness, increased innovation potential, and improved quality of life that are fully aligned with 'no harm' principles. Policy learning can help in better understanding of practical guiding principles for integrating SDGs in Smart Specialisation Strategies, inspirations on strengthening the integration of S3, SDGs and the European Green Deal, as well as alignment of top-down mission-oriented transformative research with bottom-up R&I S3 priorities. Some EU regions and countries are successfully integrating socio-economic and environmental sustainability into their Smart Specialisation Strategies including Catalunya, Slovenia, Tuscany and Wallonia, and opportunities for peer-learning should be further explored by interested regions and countries.

Ensure theoretical and conceptual plurality

The new S3 framework for the SDGs will need to build on interdisciplinary theoretical and conceptual foundations. Theoretical plurality and diverse research perspectives can help to address complex, interconnected and uncertain societal challenges. The S3 framework should be open (and remain open) to a greater variety of approaches developed in various academic traditions which share an interest in the processes of social change and sustainability.

Applying diverse theories and concepts to inform development strategies and policies is not new to policy makers and planners (Malizia et al., 2021), but the sustainability orientation creates new expectations and needs in terms of evidence, governance, innovation projects, instruments as well as monitoring and evaluation. This theoretical openness comes with challenges as there are many differences and ambiguities between different perspectives; theoretical integration itself requires an interdisciplinary debate with scholars and practitioners with different backgrounds. This report is but a modest contribution to what needs to be a broader reflexive endeavour.

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GLOSSARY

Smart Specialisation (S3) – is a place-based research and innovation agenda for regional economic transformation. S3 is a transformative, bottom-up, place-based approach to regional development that was conceptualised in the 2000s and since then has primarily found large-scale practical application in European regional policy-making. S3 valorises existing assets and local specificities while mobilising local stakeholders as key players of socio-economic sustainable growth. It supports technological as well as practice-based social innovation and responds to societal needs. Three elements make S3 a unique concept: firstly, the Entrepreneurial Discovery Process (EDP); secondly prioritisation (concentration of resources on promising R&I areas); and the third concerns inter-regional cooperation in S3 domains.

Smart Specialisation for Sustainable Development Goals (S3 for SDGs) – is a research and innovation policy approach contributing to the achievement of 17 SDGs. It is based on systemic insights and recognising the interlinkages between innovation, social and economic systems from the perspective of a territory – a country, state, province or local community. Science, technology and innovation are seen as potentially transformative activities responding to social, economic and environmental needs. S3 for SDGs promotes sustainable and inclusive growth by supporting economic, societal and environmental activities with highly transformative potential. In this context, S3 takes a roadmap approach as it leads to the identification of concrete actions and projects with the accompanying financial and organisational frameworks to achieve the objectives of the UN 2030 Agenda.

LIST OF ABBREVIATIONS

EC – European Commission

EDP – Entrepreneurial Discovery Process

EGD – European Green Deal

ESIF – European Structural and Investment Funds

EU – European Union

GHG – Greenhouse gas emissions

JRC – Directorate-General Joint Research Centre of the European Commission

MLP - Multi-level perspective

MOIP - Mission-oriented innovation policy

OECD – Organisation for Economic Co-operation and Development

R&D – Research and Development

RRI - Responsible research and innovation

S3 - Smart Specialisation Strategies

SDGs – Sustainable Development Goals

SES - Social-ecological system

S&T - Science and technology

STI – Science, technology and innovation

SNM – Strategic Niche Management

TIP - Transformative innovation policy

TM – Transition Management

UN – United Nations

IATT – Inter-Agency Task Team

LIST OF FIGURES

Figure 1
Elements of a sociotechnical system 17

Figure 2
Phases and level of transition in MLP 18

LIST OF TABLES

TABLE 1
Phrases used for the literature search in academic databases 8

TABLE 2
Advantages and limitations of the current S3 model in addressing the SDGs. 13

TABLE 3
Selected theoretical perspectives and concepts emerging from the literature review 16

TABLE 4
Transition pathways by Geels et al. (2016) 20

TABLE 5
Juxtaposing industrial transition pathways and sociotechnical transition perspective – new insights and questions for S3? 25

TABLE 6
Advantages and limitations of the sociotechnical transition perspective for embedding the SDGs in S3 28

TABLE 7
Advantages and limitations of the social-ecological perspective on embedding the SDGs in S3 31

TABLE 8
Challenge-oriented innovation policy following the principle of subsidiarity 37

TABLE 9
Integration of RRI into the S3 process 40

TABLE 10
Advantages and limitations of the challenge-led innovation policy perspective on embedding the SDGs in S3 42

TABLE 11
Key insights from the reviewed theoretical perspectives on embedding the SDGs in S3 47

TABLE 12
Implications of integrating the SDGs for the four principles of S3 53

TABLE 13
Embedding the SDGs in the main components of S3 54

ANNEXES

ANNEX.I

Tentative questionnaire for ongoing self-evaluation and reflection on embedding the SDGs in S3

The point of departure

1. Regions can address the SDGs in their S3 strategies and policies in many ways. Before answering the questions, please reflect on which of the following statements best describes your region at the moment:

- my region has not yet included a reflection on the SDGs in S3 but is planning to do so;
- my region has included the SDGs in its S3 primarily to reflect on the overall vision and impacts of the supported activities on the SDGs;
- my region has included the SDGs in its S3 and actively supports innovation niches and experimental projects which focus on sustainability challenges;
- my region has included the SDGs in its S3 and actively supports challenge-led innovation collaborations and policy mixes fostering system innovation.

2. Which of the following statements best describes the future ambition of your S3?

- My region wants to continue with the current approach.
- My region would like to include the SDGs in the overall vision and understand the impacts of the supported activities on sustainability transitions.
- My region would like to actively support innovation niches and experimental projects with a focus on sustainability challenges.
- My region would like to actively support transformative regional and interregional innovation collaborations and policies fostering system innovation.

[The final version of the questionnaire should be designed to adapt it to this initial self-assessment as well as to the stage at which the region is. The current questionnaire is designed for regions that already have S3 in place.]

Quick SDG scan

[If the answer to Q1 is 'yes']

3. Which SDGs are addressed by the S3 vision?

- [Multiple choice; list of SDGs]

4. Which SDGs are explicitly addressed by the S3 priorities?

- [Multiple choice; list of SDGs OR it could be done by S3 priority to see how regions combine different SDGs addressing different challenges]

5. Which SDGs are explicitly addressed by innovation projects supported by S3 in the region?

- [Multiple choice; list of SDGs]
- Please provide more information on these projects.

6. Which SDGs and SDG targets are included in the monitoring and evaluation system?

- [Multiple choice; list of SDGs and drop-down lists of targets]

7. Do you have evidence of the outcomes S3 has had in achieving the SDGs?

- [Multiple choice; list of SDGs and drop-down lists of targets]
- Please provide more information on the type of outcomes.

Self-assessment framework

Governance. Setting out the S3 process and governance to address the SDGs

8. Do the design and process of S3 ensure the broad, inclusive and continuous participation of stakeholders relevant to sustainability transformation in the region?

- Does S3 involve a collaboration with leading regional stakeholders and entrepreneurs pursuing sustainability goals, notably the SDGs? What are main incentives and barriers to their engagement in the process?
- Does the design and institutional setting of S3 governance ensure the continuous engagement of a variety of innovators and other stakeholders, including civil society?
- Is the process of entrepreneurial discovery designed and used to actively engage stakeholders in a challenge-driven process of learning and co-creation?
- What are the concrete arrangements to identify and address the risk of capture of the process by dominant incumbent actors who are less concerned with sustainability objectives?
- What are the key institutional and organisational challenges to addressing the SDGs in terms of knowledge, competence and capabilities? What are the key gaps and needs?

Diagnosis. Localising sustainability challenges and analysing regional innovation potential to address the SDGs

9. To what extent is the strategy design and implementation based on scientific evidence and interdisciplinary research on sustainability challenges facing the region?

- Does the diagnosis include evidence on the current and potential future impacts and risks associated with global environmental and societal challenges for the regional economy, society and natural environment?
- Does the analysis of the existing specialisations and competitive assets of the region include evidence and reflection on the strengths and weaknesses of regional actors, institutions and infrastructures to adapt and innovate to address sustainability challenges and the SDGs explicitly?

- How are various types of scientific evidence and sources of expertise on sustainability challenges and opportunities collected to support the S3 design, notably through and for the Entrepreneurial Discovery Process? How are diverse perspectives on the challenges included, including those from previously not involved or marginalised groups?

- Does the diagnosis include qualitative research on strategies objectives, vested interest, power relations and existing or potential conflicts between key stakeholders in the region which may influence collaboration and alignment in the region?

- To what extent are sustainability issues included in analytical tools used to develop S3, such as SWOT analysis and foresight tools?

Vision. Shared vision and scenarios of regional transition pathways towards the SDGs

10. What is the importance of sustainability challenges and the SDGs in the vision? Does S3 include a reflection on alternative transition pathways the region should foster for the sustainability transition?

- How does the region consider sustainability challenges and the SDGs in deliberating its S3 vision? What is the understanding of sustainability in S3 (e.g. integration of environmental, social and economic concerns, intergenerational equity, social inclusiveness and fairness, precautionary principle)?

- What is the relative importance of sustainability-oriented goals and specialisation areas compared to other goals and areas in S3?

- Does the S3 vision process, notably the prospective scenarios, include a reflection on alternative innovation choices considering their potential economic, social and environmental impacts and contributions to the SDGs locally but also internationally (e.g. scenarios, ex-ante impact assessments, etc.)?

- Was the reflection on developing 'critical mass' and a competitive advantage in the region linked to the reflection and assessment of associated environmental and societal impacts of considered development pathways?

- Does the focus on the internationalisation of SMEs and global value chains include a reflection and assessment of environmental and societal impacts associated with different options and collaborations? For example, are environmental sustainability and ethical considerations among those factors considered in the strategic positioning of the region and choice of raw material suppliers?

Priorities. Embedding the SDGs in the S3 priority areas

11. How does S3 address sustainability challenges and the SDGs in their selected priority areas?

- How relevant are sustainability-oriented goals, notably the SDGs, in the S3 priorities?

- What are incentives, drivers and barriers of including sustainability-related specialisation areas and objectives, notably the SDGs, in the S3 priorities?

- To what extent do the priorities reflect the ambition expressed in the S3 vision and alternative innovation and transition pathways explored in scenario exercises?

- To what extent are sustainable development priorities in S3 inspired and aligned with existing goals at EU, national or regional level, including other regions?

- Are any of the selected priorities focused on existing or emerging niches with a potential to experiment, demonstrate or scale transformative innovation with an ambition to address the SDGs in the region?

- What types of innovation in S3 are considered most relevant for tackling societal challenges and fostering sustainability transitions?

- To what extent are sustainability-oriented priorities based on the Entrepreneurial Discovery Process? Are the priorities aligned with the innovation strategies and sustainability goals of progressive regional stakeholders engaged in or planning to engage in innovation for sustainability?

- Are any of the selected priorities focused on seeking interregional and/or international collaboration to experiment, demonstrate or scale transformative innovation with an ambition to address the SDGs?

Policy roadmap. How are you going to get there?

12. Does the policy roadmap include a plan on how to design and ensure the coherence of specific policy portfolios and a wider policy mix to effectively foster sustainability goals?

- Does the roadmap have a dedicated focus on ensuring financial resources and dedicated instruments to address sustainability-oriented innovation projects?

- To what extent does the inclusion of sustainability goals in S3 change the design of policy instruments and policy portfolios (e.g. use of different types of instruments)? For example, do project selection and award criteria consider sustainability impacts of a proposed activity and/or its contribution to the SDGs?

- Does the roadmap include instruments designed to support the experimentation of ambitious and risky sustainability-oriented innovation projects (e.g. long duration, openness to risk and risk-sharing)? What are the barriers and drivers to developing and implementing instruments supporting such projects?

- Is the roadmap process designed to allow adjustments based on the continuous Entrepreneurial Discovery Process and stakeholder engagement and insights from monitoring and evaluation?

- Does the inclusion of sustainability goals for S3 influence require innovative mechanisms of policy coordination and collaboration between different departments and agencies?

- Does the strategy include a reflection and process to exploit synergies between different European, national and regional funding sources to pursue sustainability-oriented innovation projects?

Monitoring, evaluation and policy learning for sustainability transitions

13. Does the strategy set achievable sustainability goals and measure the progress to their achievement? How does it support a process of policy learning and adaptation? How is it to be communicated?

- Does the document identify concrete, achievable goals related to sustainable development and the SDGs?

- Is there evidence of innovations and niche experimentations supported by S3 which have generated considerable sustainability benefits? What are these impacts? What were the success factors of these projects?

- Is sustainable development considered in selecting monitoring and evaluation indicators to measure S3 outcomes and impacts? Do the metrics align with the SDG targets?

- Does the evaluation system include indicators and processes designed to capture the transformative impact of supported projects (e.g. learning effects, systemic substitution)?

- Does the governance of the evaluation and monitoring system provide for a continuous process of policy learning and experimentation, also in the area of evaluation, engaging stakeholders in a strategic reflection on the sustainability impacts of S3?

- Is the strategy and its impact on sustainability communicated to stakeholders and the gen-

eral public? Does the governance and monitoring system ensure broad continuous participation and feedback from key stakeholder groups?

Steps to align S3 with the SDGs

14. What are the key steps needed to better reflect the SDGs in the strategy?

- How do you assess advancement in the key components of the S3 strategy in relation to the sustainability goals? [Replies on the scale, as above, assessing the six components]
- What are promising or established good practices? [Open question]
- What are the gaps and barriers which need further analysis and action? Which of them can be addressed by the region and which require action at EU or national level? [Open question]
- What are the key steps for the region to address these gaps? [The steps could be distinguished between short- and medium-term actions. Respondents would be encouraged to describe how these steps can be integrated into the existing S3 processes.]

Literature review protocol

ANNEX.II

Identification and pre-screening

Publications on Smart Specialisation and sustainability

The phrase searches based on the list of keywords were conducted in Scopus, ScienceDirect, and Web of Science. The basic query – ('smart specialisation' OR 'regional innovation strategy') AND (sustainable OR sustainability) - returned 2 366 results in Scopus, 278 results in ScienceDirect and 34 results in Web of Science (topic search). The search was conducted on 13 October.

The results were first refined to filter in positions, including explicit references to both 'smart specialisation' and 'sustainable development goals'. This search returned 77 results in Scopus, 16 results in ScienceDirect (excluding encyclopaedic entries and conference abstracts) and no results in Web of Science. After removing seven duplicates, the list was narrowed to 86 documents.

In order to pre-filter relevant publications, which did not explicitly mention 'sustainable development goals', the initial results in Scopus and ScienceDirect were refined to cover review or research articles including 'sustainable development' or 'sustainability' in their keyword lists. This cut the results down to 188 documents in Scopus and 73 in Science Direct. These outputs were combined with the results from Web of Science (34), and – following the removal of 28 duplicates – resulted in the list of 267 documents. The lists combining articles on Smart Specialisation and the SDGs (86 documents) and on regional innovation policy and sustainable development (267) resulted in the list of 316 documents. 37 duplicates were removed.

Following the first screening of abstracts, we extended the query in Scopus to add documents mentioning 'regional innovation policy' (not only 'smart specialisation' and 'regional innovation strategy'). This query added nine positions to the query narrowed to the SDGs and 86 positions to the results of the broader query on sustainability. The additional search was conducted on 4 November.

Publications on regional economic development and sustainability

The extended query – (regional OR spatial OR local) AND (strategy OR policy) AND (innovation OR transition OR transformation) AND (sustainable OR sustainability) – was conducted in Scopus only. The search covered the title, abstract and keywords. It was conducted on 16 October.

The search returned 5 983 documents. In order to filter the initial results, the search was first refined to include journal articles from social sciences, business and management, economics, environmental sciences, decision sciences, arts and humanities and multi-disciplinary journals. This cut the results down to 3 481 documents. This list was further refined to cover review or research articles including keywords referring to sustainability ('sustainable development', 'sustainability', 'environmental sustainability', 'sustainability transition' and 'sustainability transitions'). This reduced the list to 1 732 documents.

As the extended query had a goal to capture the most influential publications, we limited the list retained for screening to the highest cited documents (top 10% of articles)[3]. The risk of excluding relevant positions based on this decision will be mitigated in the next step where forward and backward reference checks of the highest cited documents and consultations with experts will be conducted.

The extended list (3 481) was refined to filter in positions including explicit reference to 'sustainable development goals' i.e. (regional OR spatial OR local) AND (development OR strategy OR policy) AND (innovation OR transition OR transformation) AND ('sustainable development goals' OR SDGs). This search returned 199 results. The search was refined to cover review or research articles including keywords explicitly referring to the SDGs (i.e. 'sustainable development goal', 'sustainable development goals' and SDGs). This action reduced the list to 77 documents.

Consolidation of the lists comprising the pre-selected documents on regional development and sustainability (176 documents) and on regional development and the SDGs (77) resulted in the list containing 252 documents. One duplicate was removed.

Following the removal of duplicates, the final list combining the results from all queries came to 637 documents.

Eligibility and selection

Abstracts of 637 documents were screened to select positions with the highest relevance to the project based on research questions. Abstract screening initially limited the list to 145 positions.

The next step was to conduct full text screening. This stage aimed to retain articles with the most significance to the objectives of the project and research questions as well as to reflect the diversity of theoretical backgrounds emerging from the review. Following the full text screening, the sample was reduced to 21 positions.

The full text screening was used to conduct forward and backward reference checks for the most cited positions in the list. This helped to identify many articles not captured by the keyword search, including seminal articles which did not explicitly focus on S3 or regional innovation policy. Forward and backward reference screening identified an additional 86 positions for the reference list.

In addition, the team consulted the JRC and several experts to seek feedback on the final list. As a result, 14 additional relevant positions were added to the list and screened.

The final list of references comprised 121 documents.

Analysis

Documents were structurally coded to identify passages relevant to the research questions and S3 steps.

3 *As the 173rd article on the list was cited the same number of times as three following documents (41 citations each), we included all of them in the list.*

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