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ORIGINAL PAPER

Exploring a multiple-helix approach to local development

Alistair Adam Hernández[1] · Wilma Westin Lundqvist[2] · Fredrik Sunnemark[2] · Per Assmo[2] · Amelie Bernzen[3] · Karl Martin Born[3]

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Abstract This article elaborates on a conceptual foundation of an analytical 'multiple-helix' approach for local sustainable development. It firstly explores relevant theoretical foundations, filtering out findings and identifying knowledge gaps that can contribute to frame the concept. Through empirical enquiries, the conceptual discussion is contrasted with illustrations from the EU Interreg North Sea project called SIRR (Sustainability, Innovation and Resilience in Rural Areas). This article evaluates how an analytical multiple-helix approach can redefine stakeholder roles, power relations, and collaborative processes in local development.

Alistair Adam Hernández
alistair.adam-hernandez@uni-vechta.de

✉ Wilma Westin Lundqvist
wilma.lundqvist-westin@hv.se

Fredrik Sunnemark
fredrik.sunnemark@hv.se

Per Assmo
per.assmo@hv.se

Amelie Bernzen
amelie.bernzen@uni-vechta.de

Karl Martin Born
karl-martin.born@uni-vechta.de

1 Vechta Institute of Sustainability Transformation in Rural Areas (VISTRA), University of Vechta, Driverstraße 22, 49377 Vechta, Lower Saxony, Germany

2 School of Business, Economics and IT, University West, Gustava Melins gata 2, 461 32 Trollhättan, Sweden

3 Vechta Institute of Sustainability Transformation in Rural Areas (VISTRA), University of Vechta, Driverstraße 22, 49377 Vechta, Lower Saxony, Germany

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This study argues that the multiple-helix approach, with its inherent adaptability and fluidity, effectively engages a diverse range of stakeholders. Unlike traditional helix models that often rely on predefined categories or fixed sets of actors, a multiple-helix approach provides a dynamic, locally adaptable framework for stakeholder collaboration and innovation. This interconnectedness enables an enhanced exchange of ideas and resources across sectors, fostering innovation and holistic solutions.

However, the article highlights that further research is required to refine strategies for analysing micro-level interactions and to better understand the governance dynamics, democratic representation, and power distribution within multiple-helix collaborations. By bridging conceptual and empirical perspectives, this study contributes to the development of a more nuanced and practical analytical framework for fostering sustainable, resilient local development.

Keywords Multiple-helix · Local development · Transformation hubs · Knowledge co-creation · Learning

Erkundung eines Multiple-Helix-Ansatzes für die lokale Entwicklung

Zusammenfassung In diesem Artikel erläutern wir die konzeptionellen Grundlagen eines analytischen „Multiple-Helix"-Ansatzes für nachhaltige lokale Entwicklung. Zunächst werden relevante theoretische Grundlagen untersucht, Erkenntnisse herausgefiltert und Wissenslücken identifiziert, die zur Ausgestaltung des Konzepts beitragen können. Durch empirische Untersuchungen wird die konzeptionelle Diskussion mit Beispielen aus dem EU-Interreg-Nordseeprojekt SIRR (Sustainability, Innovation and Resilience in Rural Areas) kontrastiert. Dieser Artikel erkundet, wie ein analytischer Multiple-Helix-Ansatz die Rollen von Stakeholdern, und Machtverhältnissen sowie von kollaborativen Prozessen in der lokalen Entwicklung neu definieren kann.

Diese Studie argumentiert, dass der Multiple-Helix-Ansatz mit seiner inhärenten Anpassungsfähigkeit und Fluidität eine Vielzahl von Stakeholdern effektiv einbezieht. Im Gegensatz zu traditionellen Helix-Modellen, die oft auf vordefinierten Kategorien oder festen Akteuren beruhen, bietet ein Multiple-Helix-Ansatz einen dynamischen, lokal anpassbaren Rahmen für die Zusammenarbeit und Innovation der Stakeholder. Diese Verflechtungen ermöglichen einen verbesserten Austausch von Ideen und Ressourcen zwischen Sektoren und fördert Innovationen und ganzheitliche Lösungen.

Der Artikel hebt jedoch hervor, dass weitere Forschung erforderlich ist, um Strategien zu entwerfen, welche die Analyse und das Verständnis von Interaktionen auf Mikroebene, Governance-Dynamiken, demokratischen Repräsentativität und Machtverteilung innerhalb von Multiple-Helix-Kooperationen ermöglichen. Durch die Verbindung konzeptioneller und empirischer Perspektiven trägt diese Forschung zur Entwicklung eines differenzierteren und praktischeren Analyserahmens zur Förderung einer nachhaltigen und resilienten lokalen Entwicklung bei.

1 Introduction

Rural and coastal areas in Europe have undergone processes of structural change with broad and diverse consequences for their demographic, economic and social fabric (Humphreys and Stober 2014). Urbanisation trends has driven youth outmigration, resulting in an ageing population structure that strains healthcare, provision of schools, as well as reducing tax income. Especially peripheral areas often lack the diversity of resources and capacities to pursue endogenous path creation or diversification resulting in path dependency or even sustained development lock-ins (Sotarauta et al. 2023). This continuous path, characterized by increasing socio-economic challenges and constant infrastructural readjustment reveal a need for local communities and actors to seek a systemic and locally adaptable transformation towards more sustainable and resilient development structures in production and consumption (Köhler et al. 2019). Sustainable development, often cited in contemporary development debates, commonly refers to the WCED 'Brundtland' report, Our Common Future (1987), defined by three pillars: social, economic, and environmental. Although the sustainability concept is applied in a wide variety of ways, the dominant interpretation of sustainable development is primarily techno-economic and sector-oriented. This has resulted in policies and strategies of a general nature, which regard economic growth as a necessary precondition for achieving the (economic) strength required to tackle environmental and social problems (Schuurman 1993; Hopwood et al. 2005; Seghezzo 2009; Assmo and Wihlborg 2014).

However, such conventional top-down-oriented approaches and policies lack an explicit understanding of the complex and diverse realities at the local level. The distinctive characteristics of place are often neglected or taken for granted (Assmo 2015; Humphreys and Stober 2014). Local actors encounter interconnected challenges in context-specific ways. A genuinely integrated sustainable approach requires a more holistic perspective, understanding the interactions and constraints of the local actors concerned, integrating environmental, social, and economic aspects. By focusing on the diverse multiple actors involved, such an approach could have the potential to reach beyond contemporary conventional, sector-oriented general development policy models (Hägerstrand 1985; Widgren 2012; Assmo and Wihlborg 2012, 2014: Assmo 2015).

How path development and renewal for transformative change in local geographies take place, still requires more accurate conceptualisation. Rooted in place-based framework conditions and inherent challenges, this article integrates contextual aspects of the local to the entangled process of fostering innovation and collaboration among diverse stakeholders for transformative change. Mirrored through illustrations from an EU project focusing on local development, the aim of this article is to explore the fundamental features of a concept that can uncover the links between path development and renewal, transformation and innovation, applicable to diverse local environments, but is still under construction: a multiple-helix approach to local development.

Various helix models have been developed to address issues of regional development. From initial models focusing on three main actors, a triple helix, the models have evolved to quadruple and quintuple models to include more stakeholders.

While existing helix models provide structured approaches to stakeholder collaboration, they often struggle to capture the dynamic, fluid nature of local innovation ecosystems (Peris-Ortiz et al. 2016). There is therefore a need to explore a more flexible helix model that can be applicable to local areas.

For this purpose, this article explores what could potentially be a more interwoven actor-oriented and locally applicable analytical development perspective, namely a 'multiple-helix' approach. Research has indicated that flexible, multi-stakeholder collaboration frameworks, such as the multiple-helix, are crucial in addressing complex regional challenges (Peris-Ortiz et al. 2016; Carayannis et al. 2018). These models facilitate co-creation and knowledge-sharing, fostering local sustainability and resilience (Beer et al. 2020; Sotarauta et al. 2023). Hence, the article elaborates on how an emerging multiple-helix analytical approach could, through co-creation and sharing of knowledge, be used to grasp the complex challenges facing diverse stakeholders in local communities to enhance a more locally rooted sustainable and resilient development process.

Based on the above, the research questions are the following:

- What is the conceptual essence of an emerging multiple-helix approach seeking to understand local development?
- Who are the key players shaping co-creative processes of local transformative change?
- How can a multiple-helix analytical framework grasp the complexities facing local environments?

The structure of the article reflects its primarily conceptual nature: It begins by exploring relationships and theoretical foundations, filtering out useful findings and knowledge gaps that can contribute to frame the multiple-helix concept. The article thereafter uses the EU North Sea Interreg project—SIRR (Sustainability, Innovation, and Resilience in Rural areas) as an illustration to explore the conceptual discussion of a multiple-helix approach as an emerging analytical approach for sustainable local development. Using a qualitative approach, consisting of local surveys and interviews with local leaders in the so-called projects hubs, the article uncovers an understanding of the challenges and activities among diverse local stakeholders from different sectors in different local environments.

2 Perspectives on regional and local development

2.1 Knowledge creation and innovation

In the field of innovation studies, various models have been developed to understand the dynamics of knowledge creation and innovation. This article ties into a vast field of literature on knowledge transfer and collective learning in relation to innovation processes, not least within public projects, including those within the realm of the EU. The literature can be divided into different strands. One strand focuses on the economy and can be exemplified by Di Cagno et al. (2014) who show that knowledge transfer, understood as patents, increases with participation in EU-funded projects.

Another strand is focused on the importance of infrastructure and enabling spaces in collaborative projects to foster deepened knowledge and learning possibilities. Peschl and Fundneider (2014) show how particularly ICT infrastructures are interwoven with epistemological complexities and that the possibility for innovation is dependent on the right channels for collective learning and knowledge development.

The body of literature the paper aims to contribute to is more specifically about co-creation of knowledge and learning as tools to understand and develop innovation and social sustainability in small-scale contexts. This includes works by, e.g. Beers et al. (2003), Edwards (2009), Benn et al. (2013), Brandi and Thomassen (2021) and Olafsen et al. (2021), all of which, in different ways, focus on how knowledge is created, developed and disseminated in specific contexts.

There are many studies that show how resident participation has led to the inclusion of bottom-up perspectives in urban development (Arnstein 1969; Forrester 1988; Innes 1989; Smith 2009; Healey 2010; Hajer 2011; Brandellero and Niutta 2023). Other studies, however, point to the problems of overly powerful top-down structures (Hajer 2003; Levine 2017; Hanson 2018; Tam 2018; Anciano and Piper 2019). In relation to this dual, somewhat paradoxical picture, there is a gap in the research as to what role knowledge transfer and learning processes play in enabling and stabilizing bottom-up perspectives and, equally importantly, creating the conditions of bottom-up insights with top-down political execution.

To fill this gap, it is fruitful to turn to literature focused on the factors that enable effective knowledge transfer and learning processes in projects. There are examples such as Allix (2011), Argote (2013), Argote and Fahrenkopf (2016), Goswami and Agrawal (2020) and Stelmaszczyk (2023) among others that point to different aspects of problems and possibilities for knowledge transfer and learning processes within public project work ranging from communication and shared values to concrete time management. This is also related to organizational knowledge creation theory that is focused on identifying conditions that enable knowledge creation to improve innovation and learning (Nonaka 1994; Nonaka and Takeuchi 1995).

Following this, we are also specifically interested in how co-creative knowledge transfers and learning processes are tied to innovation. Within this more specific field of literature, there is often an economic starting point. An illustrative overview is provided by Pereira et al. (2023) who, when mapping knowledge processes in cross-border flows for innovation use this starting point to show how cross-disciplinary perspectives traditionally have interacted in understanding these processes. In this they point to both empirical and conceptual development.

Leaving the economic focus, there is also a cluster of literature on (social) sustainability, knowledge, and innovation. For example, Repo and Matschoss (2019) discuss the somewhat vague concept of social innovation and attempts to empirically operationalize it through comparing it with other innovation forms. Through a statistical analysis they conclude that social innovation can be discerned as a distinct form of innovation. Similarly, Eichler and Schwarz (2019) perform a systematic review of the social innovation literature to find its connection to sustainability goals. As the field of social innovation is still in its early stages, they conclude that in relation to implementing sustainability goals six innovation actors stand out: social

entrepreneurs, NGOs and non-profits, public institutions, civil society, firms, and social enterprises.

Various regional and local development approaches have noticeable overlaps. However, the complex and evolving challenges facing local environments require an even more flexible approach, considering the unique place and actor circumstances.

2.2 Regional innovation systems

Based on the assumption that innovations are central to driving regional development, one of the core questions in economic geography has been how aspects related to place influence innovation processes. Considering different geographical scales, several concepts and theoretical approaches deal with the role of (spatial) proximity as well as place-specific contextual factors in innovation processes, including those of industrial districts, clusters, innovative milieus, or regional innovation systems (RIS). In very general terms, this literature has highlighted the ways in which innovations are increasingly related to interorganizational interactions, arguing that geographical proximity—while by no means a precondition—can have a positive effect on knowledge exchange and creation between these organizations (Boschma 2005). Newer work has questioned the (relative) importance of geographical proximity, showing how advances in information technologies have further increased the relevance of virtual proximity for knowledge exchange, partly even replacing the need for physical presence (Grabher et al. 2018).

Using an actor-centred approach, RIS research in particular, introduced in the early 1990s (Asheim and Isaksen 1997; Cooke 1992), displays similarities to the Helix approaches discussed below. For example, Zen et al. (2023), in an bibliometric analysis assessing the evolution of innovation ecosystems literature between 2006 and 2020, subsume work on the Triple Helix models proposed by Etzkowitz and Leydesdorff (2000) as well as the Quadruple Helix models proposed by Carayannis and Campbell (2009) under the same overall cluster of literature as work on regional and national innovation systems.

Both RIS and Helix approaches stress the importance of the interplay between R&D, industry and government in driving innovation, and have in fact been termed 'competing perspective(s) on key innovation interactions' (Cooke 2005, p. 1129). Work applying RIS argues that regional differences regarding contextual factors matter, and therefore a national or supranational perspective to explain successful innovation activities is insufficient. They also emphasize geographical proximity as a factor that fosters trust in interorganizational and personal relationships, which is seen as crucial for sharing implicit knowledge. While a large range of RIS typologies has been developed over the past decades, latest approaches demand the involvement of NGOs and civil society—hence the quadruple helix (for example in the CoRIS approach or Smart Specialisation in Giustolisi et al. 2023; Schwaag Serger et al. 2023).

Yet, Asheim et al. (2019) also point to a number of conceptual differences between the Triple Helix and original RIS approach. They argue that the Triple Helix approach is rather an operationalisation of RIS and that Triple Helix shows a more explicit consideration of the government/public sector. Also, it is seen as more nor-

mative and more top-down in its approach than the RIS. They further criticise the Triple Helix approach for being too static in its application.

2.3 The evolution of helix innovation models

Some of the most prominent models in innovation studies originate from the helix family, which includes a range of frameworks from the Triple Helix to the Quintuple Helix. The Triple Helix model was first proposed in the 1990s and further developed by Etzkowitz and Klofsten (2005) as a framework emphasizing the collaboration between government, industry, and academia. This model marked a shift from the traditional linear innovation process, where innovation starts with basic research conducted in academic institutions, then moving to applied research and development in industry, and finally culminating in commercialization and market implementation. Instead, the Triple Helix introduced a more interactive approach, highlighting the importance of collaboration among multiple stakeholders in an interactive environment (Ranga and Etzkowitz 2013).

Studies examining the relationships employing the Triple Helix model have been conducted for different countries. For instance, Leydesdorff and Fritsch (2006) explored Germany's innovation system, while Lengyel and Leydesdorff (2011) investigated Hungary. Strand and Leydesdorff (2013) delved into Norway's system, and Leydesdorff et al. (2015) analysed Russia's innovation landscape. These studies have used this model to explore the dynamics of innovation in various countries, with a focus on fostering patent creation in a knowledge-based economy.

However, the limitations of the Triple Helix became evident as the innovation ecosystems continued to evolve. As society became more aware of the significance of socially responsible innovation, Carayannis and Campbell (2009, 2013) stressed the importance of involving civil society in shaping government policies related to science and technology. The Quadruple Helix model expands upon the Triple Helix by introducing a fourth helix, the 'public,' specifically defined as the 'media-based and culture-based public.' The Quadruple Helix model grew quickly in popularity and became an effective framework for addressing these new societal aspects (Miller et al. 2017). This model also facilitated the idea of 'democratizing innovation' (von Hippel 2005), where citizens are empowered as both producers and users of knowledge, contributing to the emergence of a knowledge society and knowledge democracy (Dubina et al. 2012).

While the Quadruple Helix brought civil society into the innovation process, its interpretation in literature remained flexible. Civil society has been variously understood as consumers, non-governmental organizations, or the broader community, allowing for diverse perspectives on its role within the model (Miller et al. 2017; Arnkil et al. 2010). Nonetheless, research has shown that initiatives driven by public and private institutions often fail to mobilize civil society effectively, resulting in weak or non-existent social participation (Calzada 2020). Moreover, empirical research on Quadruple Helix collaborations remains scarce, particularly regarding how these collaborations emerge and generate value at a micro level (Riconfigure Research Partnership 2018).

As innovation frameworks continued to evolve, the Quintuple Helix model emerged, further expanding the scope by incorporating the natural environment as a fifth actor. Proposed by Carayannis and Campbell (2010), this widespread model emphasizes the need to address environmental challenges within innovation systems. It situates the environment as a crucial component of knowledge production and innovation, reflecting the growing recognition of sustainability in decision-making processes (Carayannis et al. 2012). The Quintuple Helix promotes the flow of knowledge among government, industry, academia, civil society, and the environment, fostering innovations aimed at enhancing sustainability (Carayannis and Campbell 2010; Barth 2011). A less widespread interpretation of the Quintuple Helix introduced by Calzada (2020) in the context of urban and regional development conceptualizes it as 'agents playing the role of transformational intermediaries in pursuit of social entrepreneurship and activism,' specifying this additional helix as social entrepreneurs, activists, assemblers, or bricoleurs and emphasising the active role of citizenship as an agency of systemic, bottom-up, and disruptive social innovation (i.a. Calzada and Cowie 2017).

3 Methods

Methodologically, this article explores the emerging concept of a multiple-helix approach for local development in rural areas, contrasting it with relevant strands of literature and an illustrative case study grounded in the EU Interreg North Sea Project SIRR. The case study is primarily approached through a qualitative and narrative analysis (interviews with hub leaders), complemented by quantitative elements (survey of hub management), to preserve a structured and comparative approach.

3.1 Case study: the multiple-helix-Hubs in the SIRR-Project

The discussion on regional and local development above frames the multiple-helix as a more flexible alternative to existing models. To explore how this approach functions in practice, the SIRR project provides a valuable empirical case, illustrating the interactions, roles, and challenges of multiple-helix dynamics in different local contexts. The main goal of the project is to create stronger, more resilient, sustainable, and attractive rural areas by helping to unlock the full potential of collaborations and innovations within and between the respective local project partners. These so-called Multiple-Helix Hubs in SIRR, listed in Table 1 below, cover a diverse range of local features, suitable for empirical exploration in a real-world scenario.

Therefore, the case study exemplifies and highlights the practices, roles, and capacities of the hubs acting as intermediary bodies to collectively co-create innovative and territorially meaningful and sustainable solutions. This empirical enquiry especially addresses the analysis of the *who* and *how* of a multiple-helix approach to local development.

Table 1 Information on the eight hubs of the SIRR-project in France, Germany, Denmark, and Sweden. (Source: authors' own work)

Hub's name	Hub's Description	Country	Main area of influence	Responsible body/ sector	Main field of action	Degree of matureness
Sotenäs Center of Symbiosis	Marine recycling centre	Sweden	Municipality of Sotenäs	Municipality/Public	Circular economy, project facilitator	Experienced
Lysekil+	Municipality's premisses		Municipality of Lysekil	Municipality/Public	Sustainable local development facilitator	Newcomer
Læsø Tourist and Business Association	Association's premisses	Denmark	Island of Læsø	Member-driven advocacy/Business	Business and local development facilitator	Experienced
Skagen Education Centre	Education centre		Town of Skagen and municipality of Frederikshavn	Educational institution/Private non-profit	Training, idea incubator and project facilitator	Experienced
Stenvad Mosebrugscentre	Museum and cultural centre		Village Cluster 'Middle of Norddjurs'	Association/Civic	Meeting place, museum, local culture, idea incubator	Newcomer
Arobase	Community centre (Former medical centre)	France	City of Louvigné du Désert	Municipality/Public	Meeting place, coworking, idea incubator	Newcomer
Public House of Services of the Pays de Lumbres	Administration and community centre		Association of municipalities of the Pays de Lumbres	Municipality/Public	Services to the public, meeting place, citizen participation	Newcomer
TrENDi—START: PUNKT	Start-up Service at the University of Vechta	Germany	Rural districts of Vechta and Cloppeburg	Educational institution/public	Start-up counselling, meeting place, sustainability	Experienced

3.1.1 Survey

To assemble a framework that helps identify supporting and hindering factors affecting the hubs in their transformation towards a deepened multiple-helix approach, an initial online, self-administered survey of the hub management teams was conducted between July and September 2023. The aim was to collect one coordinated response per hub, resulting in a total of eight responses. The questionnaire, available in the annex, was subdivided into the following four sections: 1) the hub's definition, goals, and challenges; 2) the hub's scope, stakeholders, and user groups; 3) the hub's thematic focus and services; and 4) the hub's multiple-helix approach. The questionnaire consisted of nine multiple-choice questions and twelve open-ended questions, the latter being considered predominantly qualitative data. Accordingly, the open-ended responses were evaluated using qualitative content analysis with structure-building elements, following the methodologies of Kuckartz (2018) and Mayring (2014).

3.1.2 Interviews

Qualitative data were collected through nine semi-structured interviews (Galletta 2013) with hub leaders and managers. These interviews aimed to analyse the experiences of interviewees as active partners in the SIRR project, as well as to explore their views on the challenges, opportunities, and understandings involved in implementing and deepening a multiple-helix approach within the hubs. The interview guide was designed to explore the collaborative dynamics of the multiple-helix model, focusing on interactions between academia, industry, government, civil society, and other potential collaborators within each project hub.

Key questions encouraged participants to identify their main partners, motivations for collaboration, and ways in which these relationships strengthen local development in their area. The interviews also examined the inclusivity and equity of collaborative practices, prompting reflection on how these principles are applied across helixes. To capture the unique, place-based aspects of each hub, participants discussed local focus areas and how specific regional needs and opportunities influence project implementation and collaborations. Questions about knowledge sharing and mutual learning within the multiple-helix framework helped identify lessons from these interactions. Finally, participants were invited to reflect on recent achievements and future possibilities, envisioning how their hub could further contribute to sustainability, resilience, and innovation through the multiple-helix model.

The interviews were conducted in English via videoconference during November 2023. They were recorded, transcribed, and analysed through coding and clustering into main themes and subtopics.

3.1.3 Ethical approval

All data collection conducted as part of the SIRR project was approved by the Swedish Ethical Review Authority. Approval for the research, as outlined in application Dnr 2023-05538-01, was granted on 24 October 2023.

4 Exploring an emerging multiple-helix approach

This section introduces the concept of the multiple-helix approach as a flexible framework for local development. It examines how diverse stakeholders collaborate within the SIRR project and explores their roles, interactions, and contributions. The following subsections discuss the goals and actors involved, the role of stakeholders, learning processes, and potential barriers to implementation of a multiple-helix approach.

4.1 Goals and actors

The SIRR-hubs have a common denominator in relation to their goals and ambitions. All hubs are strongly involved in local development, where key topics are networking, training and education as well as strategic project development. In this sense, all local hubs are to some extent embedded and involved in shaping processes of structural change as well as efforts to unfold processes of transformative change. However, they aim to establish wider networks of collaboration, both within the municipality, with neighbouring regions and in some cases even internationally:

> 'The main aim for many of us is to is to establish a much stronger and wider network of collaborations.' – HL2.

Analysing the hub's core structural composition, four out of eight hubs are carried by municipal administrations as responsible bodies. In addition, two hubs comprise educational institutions as responsible bodies, a further one constitutes an association for cultural heritage, and the last one is a member-driven organisation for tourism and business. Extending the focus to the kinds of stakeholders that are *formally part of, contractually linked* with or *closely involved* in the hubs (as opposed to belonging to their wider and looser stakeholder network), we could observe that all the hubs are part of or at least include one local authority (municipality, city or county council) in their management board. Administrations of a supra-local nature, like districts or counties, are also present in most hubs. The structural relevance of local politicians though is clearly lower, as only explicitly mentioned by two out of eight hubs.

The second important constitutive sector observable at the hubs' core are businesses (mostly micro-businesses and SMEs) start-up's, entrepreneurs, trade and crafts associations or chambers and business support units of local and regional authorities. Moreover, academic and research institutions are mentioned by only three hubs as integral parts of their core, which could be attributed to their usual absence in peripheral rural and coastal areas, making interactions with academia more challenging.

> "We don't have a university here, we're not used to working with them at all, which I also know is surprising to most people." – HL7.

Nevertheless, interviewees did express the desire for greater involvement of academia and knowledge brokering organisations:

> "We do want a bit more academia, right, which is what we're trying to get [...] we try to reach out to more academia because there's no university over here." – HL2.

Finally, only two hubs mentioned explicitly local citizens, volunteers or associations belonging to their core, making clear that a quadruple or quintuple helix configuration cannot be identified in most hubs.

4.2 Stakeholders

Outside their core, the hubs interact with a diverse group of stakeholders, related to place-specific historical- and socio-economic structures. A more detailed analysis of the kinds of stakeholders belonging to each sector or helix in Fig. 1 below, shows their degree of involvement in the hub's innovation activities (*currently not, less or hardly, somewhat* and *more* or *strongly involved*). The two main groups involved in the hub's activities are local and regional authorities (not being part of the hub's core structure) including development agencies, SMEs and start-ups. This is also a result of the interviews where local and regional authorities, along with small and medium-sized businesses, including those just starting out, are confirmed as the main players.

> "We do have a lot of contacts with small and medium businesses and what you might also call pre startups like I indicated people who have an idea about something that might along the way be a business." – HL8.

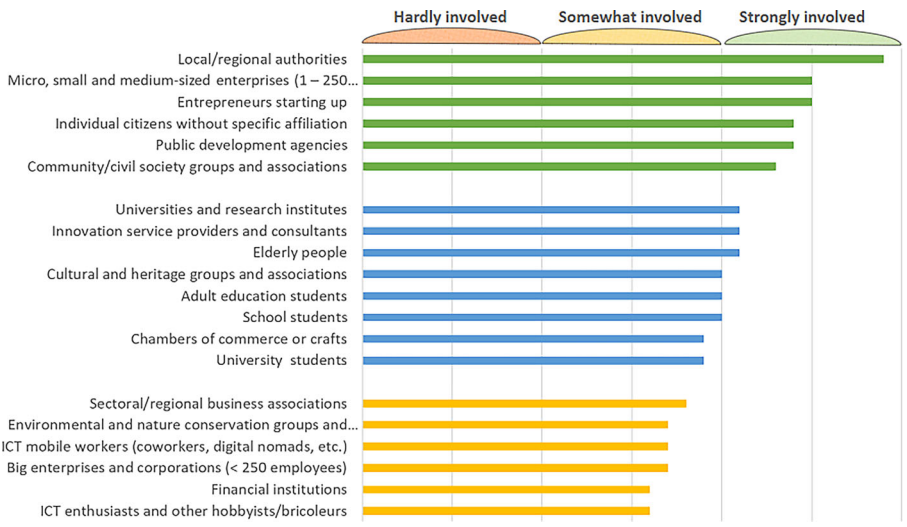

Fig. 1 Degree of participation in innovation activities of stakeholders and user groups in and around the SIRR-hubs. Note: All respondents were able to respond according to a scala with four degrees of participation. The composite score shown on the graph and reached by each user group corresponds to an overall average score of all eight hubs surveyed. (Source: authors' own work)

In the case of the newcomer hubs, civil society and community groups are generally *stronger involved* as in experienced hubs. Furthermore, stakeholders of the educational sector would be only *somewhat involved*. Finally, big enterprises or corporations, financial institutions and environmental advocacy groups are *less* or *hardly involved*, representing a relevant gap in the intended multi-stakeholder approach of most hubs.

4.3 Features of a multiple-helix hub

To capture the unique features of what could be a multiple-helix approach in each hub, the hub-managements were asked to evaluate the *visibility, involvement, influence* and *proactivity* of the different helixes in the survey. A hub manager described the multiple-helix approach as different groups coming together forming one cohesive unit:

> "Everything is sort of melted together here, like the municipality, the businesses, the civil society, academia, everything is one big blob melting" - HL2.

Not all hubs are working with all types of sectors and stakeholders. Especially the private sector and academia, and to some extent social entrepreneurs and activists, have a prominent role in the multi-stakeholder environment of the experienced hubs but are perceived to be less visible, involved, and proactive in the newcomer hubs. Lastly, an observable wider difference between the evaluation of visibility, involvement, influence, and proactivity for each helix in the less developed hubs compared to experienced hubs, could be indicative of the still pending processes of dynamization and inclusion of stakeholders and user groups in their innovation activities.

4.4 Learning in the multiple-helix approach

The journey towards effective learning within the SIRR-project still seems to be at the beginning, as the following quote illustrates:

> "We are starting from the very beginning, so all the hubs are already open for us to learn from each other, but that is not the main focus because it is quite challenging. However, there are certain strategies in place to ensure its success." – HL5.

Efforts have so far primarily focused on gathering information, identifying challenges, and sharing project-related insights, with plans to integrate replicable ideas from elsewhere into the hub's own initiatives and practices.

> "For the moment we are mainly taking notes on the initiatives of the other partners which seem to us to be replicable in our territory. It will therefore be a matter of integrating these ideas into our own consultation experiments." – HL9.

Based on mutual learning, the hubs expect to deepen their multiple-helix approach, intensifying synergies between stakeholders and integrating multiple perspectives into co-creation processes. This could allow them to meet the needs of

target groups and beneficiaries more accurately, by means of specific measures or projects.

Furthermore, processes of knowledge creation and learning within the stakeholder networks of the SIRR-hubs happen additionally to the learning and exchange foreseen in the SIRR-project. There is also a strong emphasis on the bidirectional nature of learning, which is key in the generation of value for parties exchanging knowledge. This involves observing their approaches, gathering ideas that seem replicable in their own context, and integrating them into their own practices.

> "... hopefully, it goes both ways every time we engage with some actors around our hub then then we learn, and they learn. And through the dialogue there is an exchange of knowledge, competences, and experiences. That is necessary also that there is this exchange ... it needs to be there because if not there, no not made in a new value so, so it is kind of the whole idea with the process that you share your knowledge" – HL8.

Interviewees perceive the potential to enhance the hub's capacity and efficiency by means of attracting knowledge, expertise, creativity, but also time-resources from stakeholders that they themselves can only provide to a limited extent. Some hubs are conscious of the fact that this leverage can only be achieved with sufficient institutional capacity, provided by strong linkages to local authorities and politics.

Learning to be resilient and sustainable in small societies in a local context requires a different approach compared to larger municipalities or companies. There is a focus on adapting knowledge and strategies to fit the specific local context:

> "If you want to build something you need to look into what is what is our culture what is our local identity. And I think we kind of forgot that in other parts of Europe that it is an integrated part of building a local society. Also, think about who we are and why we are here and what do we build on in our local society." – HL8.

4.5 Multiple-Helix approach for local development

The empirical findings highlight the most prominent idea attached to the concept of multiple-helix: the idea of closely working together or collaborating with a variety of others. Collaboration practices evolve from a more individualistic or limited approach towards involving anyone who can make a difference in the area and topics of influence focussed by the hubs. One of the hub leaders emphasized the imperative of inclusivity and collective action:

> "I guess it's like that idea of involving everyone because it's like maybe only the politicians have been working on, like trying to work on how to tackle the changes or maybe the associations and NGOs were doing it also, and everyone is kind of doing it apart." – HL7

Furthermore, their multiple-helix approach seems to avoid strict rules and hierarchies and prefers flexible teamwork, understanding that the group of people and organisations collaborating keeps changing over time.

> "It is never really formal. It is also changing, I guess it is like the actors are never the same exactly so it kind of changes." – HL7.

Instead of a preset of actors from defined sectors, a vivid collaborative network is activated. These findings support the theoretical claim that the multiple-helix approach accommodates diverse and shifting stakeholders more effectively than traditional helix models.

While some of the hubs have a clearer vision of a multiple-helix approach and its potential, practical implementation remains work in progress, with conceptual and methodological understandings of it still emerging and evolving.

> "We are thinking very multiple-helix, so it is also very interesting how to do it actually" – HL4.

All interviewed hub leaders agree on the variety of multiple roles that stakeholders may take on. For example, facilitators bring stakeholders and ideas together, entrepreneurs drive innovation, politicians shape policies and other organizations provide further support and resources. Amidst the network, the hub's function leans heavily towards facilitation and catalysation of ideas and projects, as highlighted by one of the hubs leaders:

> "We sort of facilitate all of that, we do all the hard work, and the goal is for them to come to us and say we would like to, to get some advice on." - HL2.

This function positions the SIRR-hubs as platforms for connection, knowledge-sharing and collective learning for meaningful societal transformations in their area of influence, rather than an authoritative entity steering development, as the following quote remarks:

> "Our project is about how other partners are going to work together. The hub is being a platform for that, actually." – HL4.

Finally, if this function is carried out successfully, high expectations arise from a multiple-helix approach to enhance the capacity and efficiency of the hubs as engines of local development. This would be possible due to the attracted additional knowledge, expertise, creativity, and other resources of stakeholders, which will then be fed synergistically into the development of transformative pathways towards sustainability.

4.6 Barriers and risks of a multiple-helix approach

All the hubs are aware of the need to tackle interdependent and complex issues of sustainable development and territorial resilience, stressing social and environmental issues of transformative change. However, a manifestly extended range of action leads to a rise in the intensity and complexity of communication, as well as expectations-management and collective decision making among stakeholders with different or even conflicting interests, as the following quote emphasizes:

"We realise that the difficulties we may encounter with certain audiences – for example, with young people – are shared by most partners" - HL9.

Apart from the already mentioned missing links to knowledge institutions, interviewees are aware of barriers to access and initiate collaboration and exchange with new kinds of stakeholders like elderly people, newcomers or institutionalised politics and business interests. To continuously align efforts, interests and expectations in the core and looser network of the hubs, a noticeable increase in staff, skills and financial resources is viewed as prerequisite to effectuate a successful pathway towards a multiple-helix approach.

Finally, some hubs consider issues of democratic and balanced representation within the initiated processes of participation and co-creation as well as in the hub's steering bodies themselves as potential barriers for a successful multiple-helix approach that catalyses processes of transformative change in their areas of influence.

5 Discussion

5.1 Conceptual development towards a multiple-helix approach

In the broad literature domain of helix innovation frameworks, the explicit use of multiple-helix as a separate and characteristic approach is noticeably limited. It is mostly used as an umbrella term to simultaneously consider more than one of the existing and well-known triple-, quadruple- or quintuple-helix frameworks (e.g.: Gerli et al. 2020; Larsson 2018; Schütz et al. 2018).

Some authors (Peris-Ortiz et al. 2016) conceptualise multiple-helix as a generic model where '*more helixes […] can claim relevance in the context of economies and firms*' depending on the R&D + I collaboration or innovation in question. Moreover, the limited literature mainly aims to explain collaborative interaction for innovation, knowledge, and technology transfer in the context of companies and economies (Peris-Ortiz et al. 2016), ignoring similar phenomena in the social and environmental realms. Furthermore, there is a need including stakeholders to nurture cross-sectoral interactions and collaborations.

Moving towards exploring a multiple-helix approach could enhance a more flexible approach that is better suited and applicable to understand and analyse the complexity facing local environments. The focus should be on the constituting active elements of a local innovation ecosystem: the stakeholders, who usually belong to multiple sectors. Another feature interpreted to be multiple refers to the different modes of knowledge production (Carayannis et al. 2018). This indicates that an emerging multiple-helix approach could offer a certain flexibility in creating more holistic innovation processes adjusted to local circumstances and contexts. It also offers a way of understanding such processes through analysing what specific flows of influence and knowledge that can be detected and how they interact.

Furthermore, the unique complexity of a local environment require that place is taken into consideration. The development path applied in economic geography has

mainly focused on institutional and industrial actors shaping regional development (Sotarauta et al. 2023). Many local areas lack the capacity for path creation or substantial unrelated path diversification, resulting in entrapment within downward spirals (Isaksen and Trippl 2017).

Research has called for attention to focus on how multiple actors at a local level intentionally construct the desired development pathways (Dawley 2014; Grillitsch and Sotarauta 2020; MacNeill and Steiner 2010). New pathways seem to emerge, when complex and usually fragmented multi-actor and multi-interest constellations are successfully orchestrated and influenced (Beer et al. 2020) by an entity capable of aligning individual actor's goals and pooling skills, power and resources of a complex actor-network for common local goals in a coherent way (Beer et al. 2020; Gibney and Nicholds 2021; Hambleton 2014; Sotarauta and Beer 2021).

5.2 Empirical observations

The following chapter integrates the conceptual discussion and the findings from the illustrative empirical example of the EU Interreg North Sea SIRR-project. Through this analysis, three main dimensions illuminate as important aspect to consider for multiple-helix analytical framework focusing on transformative processes of change in diverse local environments.

5.2.1 Place and space context

A multiple-helix approach can pay special attention to the spatial local context. A multiple-helix analytical approach can explore, understand, and analyse local conditions, interactions, and development trajectories, applicable to a certain place. Stakeholders' challenges and opportunities are determined by place and spatial context and also relate to the unique strength and legitimacy of specific stakeholder-groups in different sectors in the local environment.

The importance of place context is also crucial to understand how given or intentionally enabled proximity is linked to innovation interactions with like-minded or unexpected stakeholders. Furthermore, the role of local public authorities is largely bounded by place-specific scope of action, which can strongly influence the possibilities and effectiveness of different local development and innovation initiatives.

5.2.2 Multiple stakeholders and collaboration

Instead of aiming for a preset of stakeholders from defined sectors and/or actors, a local oriented multiple-helix approach should enable the inclusion of various place dependent stakeholders and sectors, forming collaboration to enhance locally adaptable and relevant development pathways in the local environment.

Besides the well-known classic sectors of academia, business, administration, and civic society, the multiple-helix approach should also accommodate other locally important stakeholders such as community enterprises, environmental organisations, social entrepreneurs, activists or simply unorganised members of civil society. The

approach should strongly focus on explaining how various stakeholders interact and create value for themselves and for places by means of collaboration and innovation.

The more maturely established hubs tend to have a more structural composition and wider more formal stakeholder networks. Due to their typically public or semi-public organisational nature and financing, they can be described as a classic '*support structure*' or incubators. The more recently established hubs, however, are often stronger aligned with stakeholders like civic society and environmental advocacy, but less pronounced in the case of including academia. The local hubs of the SIRR-project attempt to counteract imbalances by questioning their approaches and improving their skills of stakeholder engagement. They instigate collaboration, coordinate stakeholder engagement, and sometimes participate directly in the steering of such collaborations. Successful inclusion of further stakeholders for effective collaboration and knowledge co-creation can occur, when trust is built and relationships nurtured among stakeholders.

5.2.3 Knowledge co-creation and learning

Deriving from the literature review and case study, innovation processes should be understood as allowing for the creation and exchange of knowledge among local stakeholders. This possibility of 'co-creating knowledge' in partnership with others, also outside classic innovation settings and collaborations, can contribute to more sustainable local development processes of change. These co-creative interactions can be based on the experiences, expertise, skills, and other resources available among the local stakeholders.

The SIRR-hubs illustrate platforms for participation, knowledge-sharing, and collective learning that can foster meaningful local societal transformations, rather than acting as an authoritative steering entity. Yet, several organisational and place related obstacles can hinder the capacity as knowledge co-creation and innovation brokers of the SIRR-hubs.

As previously discussed, academic and knowledge institutions are weekly represented in the core composition and closer networks of most hubs. Also, implementation of local innovative solutions and strategies still require further adaptation and learning processes to be applicable due to aspects of local culture and identity.

6 Conclusions and outlook

This article contributes to conceptualise pathways of transformative change in local areas and contexts. It explores the foundations and possible features of an emerging multiple-helix approach to local development as an analytical concept, tied to relevant strands of literature in the realm of regional innovation and development. The proposed conceptual development includes three significant dimensions: place, stakeholders and collaboration, and co-creation of knowledge and learning.

Emerging concepts like 'multiple-helix' largely lack contextualisation, which might make it difficult to comprehend or implement. The literature review aimed to connect it to established theories and concepts like regional innovations systems,

knowledge creation, existing helix innovation in regional development, to create a basis for its conceptual development.

The review reinforces the notion that place matter and confirms the need for a conceptual framework that compensates the deficits of existing helix models and regional innovation systems, able to shift from a national or supranational perspective and that can capture place-specific and contextual factors at a local or micro-level.

Also, the active stimulation and coordination of multiple stakeholders for collaboration matters. The detailed analysis of multi-actor and multi-interest collaborations orientated towards transformative pathways of change in regional development represents significant gap that a multiple-helix conceptual approach can help to bridge.

Although the conceptual widening of quadruple and quintuple helix provides crucial additional layers of analysis and embeddedness of collaboration processes with an innovative outcome, we identify the mechanisms facilitating the co-creation of knowledge and sharing among the involved stakeholders in real-world scenarios, especially in local areas. Therefore, understanding knowledge co-creation and learning in local development better significantly matters.

Although significant features of the emerging multiple-helix concept could be identified, further in-depth research of the micro-interactions among stakeholders within the multiple-helix approach is required to strengthen its conceptual foundation. The empirical efforts performed in the context the SIRR-project must be considered as a contextualising exemplification, and further empirical analysis is required to investigate all gathered indications and emerging hypotheses with a wider data base. Hence, a more specific and contrasted operationalisation of a multiple-helix analytical approach to local development requires further research.

7 Appendix

Table 2 List of Hub leader interviewees. (Source: Authors' own work)

No. of interviews	Date	Hub country	Gender
HL 1	November 1, 2023	Sweden	Female
HL 2	November 6, 2023	Denmark	Female
HL 3	November 7, 2023	Sweden	Female
HL 4	November 7, 2023	Denmark	Female
HL 5	November 8, 2023	France	Male
HL 6	November 9, 2023	Germany	Female
HL 7	November 16, 2023	France	Female
HL 8	November 16, 2023	Denmark	Male
HL 9	November 27, 2023	France	Female

Notes: *HL* hub leader

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