Living Labs and user engagement for innovation and sustainability

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ARTICLE INFO

ABSTRACT

This exploratory study, investigating the role of Living Labs (LLs) in promoting innovation and sustainability, has two main goals. Firstly, it seeks to understand how stakeholders and users, in a Quadruple Helix Model, can participate in LL activities and support the process of achieving a more sustainable society. Secondly, it guides the setting up of LLs with the aim of directly contributing to the United Nations Sustainable Development Goals (UN SDGs). Research, based on a multiple case study, has shown that LLs are able to actively engage users, including firms and business systems, in promoting co-creation of value so as to benefit the economy, society and the environment. We have selected some good practices and derived some policy implications that could inspire LLs to promote innovation and encourage transition towards sustainable development at the local level, within the context of a QHM model.

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1. Introduction

The global economy is moving towards a knowledge-intensive model and the European Union (EU) has identified innovation as a key driver (Gray et al., 2014) for economic and social growth. At the same time, sustainability has increasingly become a global challenge (Hossain et al., 2019). Indeed, in September 2015, 193 countries met to define and adopt the 17 Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development. Companies, individuals, governments, universities and non-governmental organizations (NGOs) must all contribute to protect the planet, to end poverty and to ensure peace and prosperity (UN General Assembly, 2015). Although various studies have dealt with sustainable development and innovation (Mulder, 2007), the relationship between innovation and sustainability processes is neither obvious nor simple. Indeed, sustainable development can only be a structural driver for innovation if it is pursued adopting a trans-disciplinary approach (Fourati-Jamoussi et al., 2019).

Thus, European policy makers are being encouraged to strengthen the capacity of regions to support innovation and strategic knowledge assets (Etzkowitz and Klofsten, 2005), which are based on sustainable, trans-disciplinary and hybridized approaches (Arnkil et al., 2010). Furthermore, governments have invited universities to contribute to innovation and sustainable development by working with scholars, faculty staff and students and, with their stakeholders (Purcell et al., 2019). Along with governments, both NGOs and business corporations can also play a vital role in achieving sustainability (Weiss and Gordenker, 1996). Moreover, multinational corporations (MNCs) and companies are legally constrained to adopt sustainable practices with both their stakeholders and with society (Abad-Segura et al., 2019). Indeed, MNCs can fruitfully engage with the SDGs on voluntary basis too, if they are prepared to broaden their interpretation of business sustainability and to reflect upon their values (Fleming et al., 2017). Indeed, in response to calls from the global community, companies are increasingly adopting a variety of voluntary practices in order to improve the environmental and/or social management of their suppliers' activities (Thorlakson et al., 2017). However, even though companies in the major emerging national economies have been trying to adopt UN SDGs, some important goals have not yet been achieved (Ali et al., 2018).

To meet these challenges, some have suggested adopting the Triple Helix Model (THM) for innovation (Etzkowitz, 1998, 2003)

as a possible source of inspiration for local development policy-makers (Rodrigues and Melo, 2012), since it brings together industries, universities, and Government. However, predominantly innovation-based collaboration between these stakeholders, may simply not be enough to meet, and satisfy, the real needs of society (Gray et al., 2014). Indeed, the THM has progressively given way to the Quadruple Helix Model (QHM) (Priday and Pedell, 2017) which was originally described by Carayannis and Campbell (2009) and Yawson (2009). Crucially, the QHM also considers the citizens themselves to be key actors in a regional innovation ecosystem (Carayannis et al., 2012; Leydesdorff, 2012). As highlighted by Almirall et al. (2012), when Time Magazine (TIME USA LLC, 2006) selected "the user" as the person of the year for its front page, it was acknowledging the growing importance of citizen involvement in innovation processes. This inclusion, offered by the fourth helix is crucial, because scientific knowledge is also evaluated on the basis of its social robustness, inclusivity and sustainability (Arnkil et al., 2010). Indeed, over the past fifteen years Europe has been shifting its focus onto public and private linkages by placing citizens at the heart of the innovation process (European Commission, 2013; Priday and Pedell, 2017). To achieve their target, the European Commission (EC) has, since 2006, been promoting Living Labs (LLs). LLs have been recognized as a innovative tool that offers opportunities for testing, validation, development and co-creation at all stages of a design and commercialization process (Buhl et al., 2017; Leminen et al., 2017) by synchronizing the innovation processes among the actors of the QHM (Issa et al., 2018). In other words, LLs have been proposed as a possible platform for quadruple helix innovation (European Commission, 2016; Priday and Pedell, 2017).

The LL model, as innovation platform, has been studied in relation to sustainability (e.g. Bakıcı et al., 2013) and users. LLs can become part of a transformative institutional change that draws on both top-down and bottom-up strategies in the pursuit of sustainability (Purcell et al., 2019). The literature states that LLs emerge as a type of collective governance and experimentation carried out, especially in urban areas, to address sustainability (Voytenko et al., 2016). Indeed, LLs are seen as a practical methodology for improving sustainability in cities by facilitating both collaborative learning and innovation by responding directly to the needs of users (Van Geenhuizen, 2019). Levenda (2019) has investigated LLs and citizens as key actors in experimentation that seeks wider sustainability transitions. Furthermore, the literature has recently analyzed the potential of LLs to anchor sustainability both within the functioning of the university itself and in its interactions with the neighborhood (Trencher et al., 2014; Vargas et al., 2019).

Although LLs have become a popular tool (Franz, 2015), their nature remains underexplored (Hossain et al., 2019). From the general point of view, LLs are neither backed up by a consistent research stream nor by supporting theories (Eriksson et al., 2005; Ståhlbröst and Bergvall-Kåreborn, 2008). In particular, the role of stakeholders is unclear within LLs (Leminen et al., 2015a) and there is a lack of understanding about the relationship between LLs and user communities (Hossain et al., 2019). Methods, structures and practices should be further analyzed within LLs in order to ensure both knowledge sharing and effective interactions between QHM actors, (Franz, 2015; Friedman and Miles, 2006; Mainardes et al., 2011; Vecchio et al., 2017).

However, from a sustainability perspective, the way in which LLs contribute to sustainability transitions has yet to be explored (Von Wirth et al., 2019), as does just how the co-creation of knowledge and practices takes place within LLs to address sustainability challenges (Puerari et al., 2018). At the same time, there is also a need to focus on how the involvement of stakeholders can

facilitate the achievement of sustainability targets (Menny et al., 2018).

This exploratory study seeks to contribute both to the literature on LLs and on their role in promoting innovation and sustainability, through engaging users. The paper has two aims. Firstly, it seeks to understand how QHM stakeholders participate in LL activities and the way in which they contribute to achieving UN SDGs. Secondly, the paper intends to promote the setting up of LLs, by identifying some good practices that could support user engagement in the process of sustainable product and service innovation. To do this, we have used a multiple case study methodology which involves the partners in the Horizon 2020 Twinning Programme "Alhtour - Assisted Living technologies for the Health Tourism sector" and their LLs, and the University of Lisbon. The LLs include CreaHUB (University of Macerata - Italy) which is an LL on creativity and innovation, the Living Lab on Ageing and Long-Term Care (Maastricht University - The Netherlands) and InnovAge (The Catholic University of Leuven - Belgium).

Given the aims, and activities, carried out by the LLs selected, the study focuses on the following UN SDGs: SDG.9. "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation" with reference to target 9.5.[1]; SDG.11. "Make cities and human settlements inclusive, safe, resilient and sustainable" with reference to target 11.A.[2]; and SDG.17. "Strengthen the means of implementation and revitalize the global partnership for sustainable development" with reference to targets 17.16. and 17.17.[3]

The paper addresses the following research questions:

1. How can LLs support interactions between users, universities, industry, and governments within the QHM?
2. How can LLs intercept and absorb the contribution of stakeholders within the innovation process of sustainable products and services?
3. How can LLs contribute to achieving SDGs, with particular reference to SDGs 9.5., 11.A., 17.16. and 17.17.?

The intended audience for this paper is scholars, LL designers and policy makers.

The remainder of this paper is structured as follows. Section 2 sets out the theoretical framework. It provides an overview of the definition, origins and evolution of LLs in Europe, and reviews the literature of the QHM for innovation of civil society-academia-industry-government relations, emphasizing the role LLs as innovation platforms. It then outlines the relationship between LLs, users, and sustainability. Section 3 focuses on the methodology, including case studies, data collection, and survey coding. Results and discussion (4) follow. Lastly, Section 5 offers conclusions and suggests avenues for future research.

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[1] Target 9.5. "Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending".

[2] Target 11.A. "Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning".

[3] Target 17.16. "Enhance the global partnership for sustainable development, complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology and financial resources, to support the achievement of the sustainable development goals in all countries, in particular developing countries". Target 17.17. "Encourage and promote effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships".

Table 1
Different perspectives on LLs (Source: Authors' elaboration).

Definition	Sources
LLs include "a research methodology for sensing, prototyping, validating and refining complex solutions in multiple and evolving real-life contexts"	Eriksson et al. (2005)
An LL is "an experimentation environment in which technology is given shape in real-life contexts and in which (end) users are considered 'co-producers'"	Ballon et al. (2005)
An LL represents "an R&D methodology where innovations, such as new services and products, or application enhancements, are created and validated in collaborative, multi-contextual, empirical, real-world environments within individual regions"	de Leon et al. (2006)
LLs "are experimentation and validation environments characterized by early involvement of user communities, closely working together with developers and other stakeholders, and driving rapid cycles of ICT-based innovations"	Schaffers and Kulkki (2007)
LLs are "collaborations of public-private-civic partnerships in which stakeholders co-create new products, services, businesses and technologies in real-life environments and virtual networks in multi-contextual spheres"	Feurstein et al. (2008)
An LL is an innovation intermediary community which shares the view of a user innovation approach	Ståhlbröst and Bergvall-Kåreborn (2008)
An LL consists of a social configuration which is arranged for innovation creation by contact, communication and collaboration	Dutilleul et al. (2010)
An LL is an enhancement or implementation of public and user involvement, such as a public-private-people partnership (4Ps or quadruple helix)	(Arnkil et al., 2010; Ferrari et al., 2011; Molinari, 2011)
LLs are "open innovation intermediaries that seek to mediate between users, research, and public and private organizations, (and to) advance our concept of technology transfer by incorporating not only the user-based experimentation, but also by engaging firms and public organizations in a process of learning and the creation of pre-commercial demand"	Almirall and Wareham (2011)
LLs are "experimentation environments: (they) are physical regions or virtual realities where stakeholders form public-private-people partnerships (4Ps) of firms, public agencies, universities, institutes, and users all collaborating for creation, prototyping, validating, and testing new technologies, services, products and systems in real-life contexts"	Westerlund and Leminen (2011)
An LL is an innovation intermediary community which shares the view of a user innovation approach	Stahlbrost and Kareborn (2011)
An LL is "a user-centered open innovation ecosystem integrating research and innovation within a public-private-people partnership (PPPP) through an iterative Experiential Design process"	Pallot and Pawar (2012)
An LL provides "a setting for collaborative innovation by offering a collaborative platform for research, development, and experimentation with product and service innovations in real-life contexts, based on specific methodologies and tools, and implemented through concrete innovation projects and community-building activities"	Schaffers and Turkama (2012)
An LL is a multi-actor innovation network which "employs heterogeneous roles and resources", "shares information to enable flexibility", "reveals undefined and later need", and where the "lack of strict objectives guides collaboration and outcomes"	Leminen and Westerlund (2012)
LLs are a way to catalyze regional systems of innovation, strengthening and making more effective the organization's innovation capabilities and reducing market-based risk	(Franz, 2015; Kviselius et al., 2009; McPhee et al., 2013)
LLs "represent a pragmatic approach to innovation (of ICTs and other artifacts), characterized by experimentation in real-life and active involvement of users"	Ballon and Schuurman (2015)

2. Theoretical framework

2.1. Living Labs in Europe: definition, origin and evolution

The LL concept first appeared in academic discussions in the 1990s. The term LL was introduced by Prof. William Mitchell at Massachusetts Institute of Technology in the early 2000s, to describe a user-centric research methodology for sensing, prototyping, validating and refining complex solutions in multiple and evolving real life contexts (Eriksson et al., 2006; Van Geenhuizen, 2019). In Europe, LLs only really took off in 2006, when the European Commission (EC) funded *Corelabs* and *Clocks*, two projects that sought to create policy measures which could advance, coordinate and promote a common European innovation system (Dutilleul et al., 2010; Veeckman et al., 2013). The pan-European network ENoLL (European Network of Living Labs), consisting of 19 core LLs, was set up around the same time. ENoLL has pursued the objective of tackling Europe's declining economic competitiveness and societal challenges (Mastelic et al., 2015; Ståhlbröst, 2013). Two years later, European LLs were further supported when another EC initiative, "Strengthening Innovation and Investment in ICT research" was set up (Peltomäki, 2008).

Although there have been numerous attempts to define what an LL is (Table 1), there is still no, one, widely accepted definition (Baccarne et al., 2013; Dell'Era and Landoni, 2014; Følstad, 2008; Kviselius et al., 2009; Leminen et al., 2015a; Tang et al., 2012). It was only in the 2000s that LLs finally evolved from being seen only as a research infrastructure, such as a building, or a set of buildings, replicating a home with the facilities to support temporary residents/experimental subjects, and began to be acknowledged as a dynamic multi-stakeholder network: a network that aims to boost and manage user-driven innovation in real-world settings (Pino et al., 2014), or to stimulate interaction between technological and socio-economic forces (Franz et al., 2015; Pascu and van Lieshout, 2009).

According to the European Commission (2009), an LL is defined by the four "P's", public-private-people-partnership, as the focus of collaboration. More specifically, an LL is "a user-driven open innovation ecosystem based on a business-citizens-government partnership which enables users to take active part in the research, development and innovation process". This definition was also offered by Leminen et al. (2012) who were the first to support the goal of collaboration in order to create, prototype, validate and test new technologies, services, products and systems in real-life contexts. The ENoLL defines LLs as "user-centered, open innovation ecosystems based on a systematic user co-creation approach, integrating research and innovation processes in real-life communities and settings". Furthermore, ENoLL argues that LLs act as "intermediaries between citizens, research organizations, companies, cities and regions for joint value co-creation, rapid prototyping or validation to scale up innovation and businesses."[4]

Scholars have yet to agree upon a definition of an LL because it is still an evolving and noteworthy topic in the field of open and user innovation (McPhee et al., 2012). Indeed, LLs cover a wide range of fields and sectors, and also include a wide variety of expertise as well (Kviselius et al., 2009). However, a recent systematic literature review carried by Hossain et al. (2019) has identified the state of the art key characteristics of LLs (Table 2).

As far as what could be described as current thinking is concerned, besides being test-beds for new products, services, systems and solutions, LLs also provide a platform for collective innovation and development and a source of information (Almirall and Wareham, 2011; Leminen et al., 2015b). Moreover, LLs make it

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[4] (openlivinglabs.eu/aboutus).

possible to cut innovation costs, to reduce market-based risk (McPhee et al., 2013) and to spread research costs (Kviselius et al., 2009). Furthermore, LLs facilitate cost-sharing for experimental and service delivery infrastructures (de Leon et al., 2006; Dutilleul et al., 2010). Thus, LLs are attracting more and more attention as they offer an interesting example of a network-based form of multi-actor collaboration (Dell'Era and Landoni, 2014; Leminen et al., 2015b; 2012; McPhee et al., 2016). Indeed, LLs operate as an open and dynamic research and innovation ecosystem involving solution developers (technology push), research labs and universities (knowledge and technology), local authorities and policy makers (inclusion and social wealth), and user communities (application pull) (Leminen et al., 2012; Vecchio et al., 2017).

Leminen et al. (2012) distinguish four models of LLs (Table 3) on the basis of the type of actor that drives the activities of the LL: i) utilizer-driven LLs, which are mainly managed by companies to develop their business; ii) enabler-driven LLs, which are public sector projects built around regional development targets; iii) provider-driven LLs launched by developer organizations, such as educational institutes, universities or consultants, to promote research and knowledge creation; and iv) user-driven LLs, established by the user community itself, that focus on addressing specific challenges for the users and, consequently, benefitting other stakeholders either directly or indirectly.

Users were only recently included in the list of main LL stakeholders. Encouraged by several European initiatives, LLs are now seen as offering an opportunity for actively involving users in innovation activities, both in public-private-people partnerships and in real-life environments (McPhee et al, 2015, 2016; Schuurman and Marez, 2012). In other words, LLs offer an explorative and user-centered space combining research with innovation processes (Franz, 2015), one that turns users from being mere, observed subjects, into active participants, co-creators of value (McPhee et al., 2012).

2.2. The Living Lab as an innovation platform for the Quadruple Helix Model

The European Union is extremely effective when producing knowledge, but not as effective when it seeks to transfer it to the market (Compagnucci and Spigarelli, 2018). Indeed, Europe sometimes fails to turn knowledge into added value either for society or for markets (Barbieri et al., 2013; Conti and Gaule, 2011). A THM for innovation (Etzkowitz, 1998, 2003) could prove useful when addressing this knowledge/value issue by offering suggestions, thus becoming a source of inspiration, for local development policy (Rodrigues and Melo, 2012). A THM is a key component of any national or multi-national innovation strategy (Etzkowitz and Leydesdorff, 1997), as well as being important for reducing some factors hindering regional development (Etzkowitz and Ranga, 2010). The model describes the formation of a knowledge-intensive society which is based on cooperation between

academia, industry, and government (Etzkowitz and de Mello, 2004). Furthermore, a THM is considered to be a point of reference for designing policies that aim to improve both the conditions and the support for innovation processes (Rodrigues and Melo, 2013) that take place across national boundaries through cooperative arrangements between regions and firms (Etzkowitz and Leydesdorff, 1997; Kohler-Koch, 1995). Indeed, institutional spheres may converge and boundaries become blurred and, academia too, plays a crucial role in fostering innovation (Leydesdorff and Etzkowitz, 2001).

However, innovation-based collaboration between industry, academia, and government, may not be enough to really address, and meet, the needs of citizens and the emerging challenges related to sustainable development (Gray et al., 2014). Consequently, the THM for innovation has progressively given way to the Quadruple Helix Model (QHM) (Priday and Pedell, 2017), which was initially suggested by Carayannis and Campbell (2009) and Yawson (2009). A THM has 3 actors, while a QHM introduces a fourth helix: Civil Society. A QHM considers citizens as key actors in a regional innovation ecosystem (Carayannis et al., 2012; Leydesdorff, 2012), as co-creators of a future that goes far beyond the scope of what any one organization, or person, could do alone (Priday and Pedell, 2017). In this model, citizens are not only involved in product development and testing, rather, they actively participate in developments by suggesting new innovations, thus connecting users to stakeholders (Arnkil et al., 2010). Indeed, the QHM encompasses user-oriented innovation models, to take advantage of the cross-fertilization of ideas that leads to experimentation, and to prototyping in a real-world setting (Ballon and Schuurman, 2015; Priday and Pedell, 2017).

The inclusion of the fourth helix is crucial because scientific knowledge is also evaluated for its social robustness and inclusivity (Arnkil et al., 2010). Indeed, Europe has recently shifted public and private linkages towards placing citizens at the heart of the innovation process (European Commission, 2013; Priday and Pedell, 2017). Within such a process, scholars, entrepreneurs, and policy makers are all called upon to cooperate through more direct, and dynamic, involvement of citizens (Vecchio et al., 2017). To do this, the European Commission started to introduce LLs in 2006. LLs were, and are, promoted as a novel tool that offers a space for testing, validation, development and co-creation at all stages of a design and commercialization process (Buhl et al., 2017; Leminen et al., 2017) by synchronizing the innovation process among QHM stakeholders (Issa et al., 2018). In other words, the LL is emerging as a platform for quadruple helix innovation (European Commission, 2016; Priday and Pedell, 2017) where competencies and competitive advantage can be enhanced (Dell'Era and Landoni, 2014; Leminen et al., 2012; Pascu and van Lieshout, 2009).

The creation of LLs is just one of the responses of the EU, introduced in the context of the QHM, to tackle economic competitiveness, and societal and sustainable challenges, (Dutilleul et al., 2010). In particular, LLs are designed to, hopefully, overcome

Table 2
Key characteristics of LLs based on the existing literature (Source: Hossain et al., 2019).

Characteristics	Sources
Real-life environments (context)	(Bergvall-Kåreborn et al., 2009; Følstad, 2008; Leminen and Westerlund, 2016; Mulder et al., 2008; Voytenko et al., 2016)
Stakeholders	(Bergvall-Kåreborn et al., 2009; Følstad, 2008; Leminen and Westerlund, 2016; Mulder et al., 2008; Voytenko et al., 2016)
Activities	(Følstad, 2008; Leminen and Westerlund, 2016; Mulder et al., 2008; Voytenko et al., 2016)
Business models and networks	(Bergvall-Kåreborn et al., 2009; Leminen and Westerlund, 2016; Mulder et al., 2008; Voytenko et al., 2016)
Methods, tools, and approaches	(Bergvall-Kåreborn et al., 2009; Leminen and Westerlund, 2016; Mulder et al., 2008)
Challenges	(Følstad, 2008; Guzmán et al., 2013; Leminen et al., 2015a)
Outcomes	(Følstad, 2008; Leminen and Westerlund, 2016; Mulder et al., 2008)
Sustainability	(Bakıcı et al., 2013; Leminen et al., 2016; Nevens et al., 2013; Nyström et al., 2014; Rodrigues and Franco, 2018)

Table 3
Models of LLs according to the type of actors (Source: Authors' elaboration of (Leminen et al., 2012)).

Characteristic	Model of Living Labs			
	Utilizer-driven	Enabler-driven	Provider-driven	User-driven
Purpose	Strategic R&D activity with preset targets	Strategy development through action	Operations development through increased knowledge	Problem solving by collaborative accomplishments
Organization	The network forms around a utilizer, who organizes action for rapid knowledge result	The network forms around a region (regional development) or a funded project (e.g. public funding)	The network forms around a provider organization(s)	The network is initiated by users and lacks formal coordination mechanisms
Action	Utilizer guides information collection from the users and promotes knowledge creation that supports achieving preset goals	Information is collected and used together, and knowledge is co-created in the network	Information is collected for either immediate or postponed use; new knowledge is based on the information that the provider obtains from the others	Information is not collected formally and builds upon users' interests; knowledge is utilized in the network to help the user community
Outcomes	New knowledge for product and business development	Guided strategy change into a preferred direction	New knowledge supporting operations development	Solutions to users' everyday-life problems
Lifespan	Short	Short/medium/long	Short/medium/long	Long

the so-called "European Paradox", namely the gap between knowledge production and knowledge transfer, and the commercial success of innovation (Almirall and Wareham, 2011; Herranz and Ruiz-Castillo, 2013). In the QHM framework, LLs are mediators between innovation stakeholders (Almirall and Wareham, 2011; Ståhlbröst, 2012) and are designed to stimulate interaction between technological and socio-economic forces (Pascu and van Lieshout, 2009). They offer the potential for academia, industry and society to co-create knowledge, products and services (Almirall et al., 2012).

2.3. Living Labs, users and sustainability

Sustainability has been defined as "development that meets the needs of the present while safeguarding Earth's life-support system, on which the welfare of both current and future generations depends" (Griggs et al., 2013). According to Vargas et al. (2019), sustainability is an equilibrium among the ecological, social and economic dimensions of human life. In the context of an LL, sustainability refers to its viability and responsibility to the community within which it operates (Bergvall- Kåreborn et al., 2009). This means that LLs are able to be concerned with environmental, economic and social effects (Hossain et al., 2019).

Recently there has been renewed interest in LLs as a sustainability-oriented cross-cutting approach to the SDGs (Trencher et al., 2014; Evans et al., 2015). LLs can frame co-creation for sustainability in two ways: firstly, consulting users and stakeholders allows complementary sets of projects to offer holistic solutions to sustainability challenges; secondly, LLs are able to develop the iterative process of experimenting and learning from year to year. This means that they are able to provide a coherent basis for action over time (Evans et al., 2015). In particular, users can be engaged within LLs to contribute to designing and developing innovations (Nyström et al., 2014) and, also, to testing new ways of addressing sustainability challenges (Bulkeley et al., 2016). In this sense, an LL could be broadly defined as a situation, or circumstance, where real-world sustainability challenges are formally addressed in stakeholder partnerships (König and Evans, 2013).

Thus, along with the 'archetype' of LLs as test-beds, LLs can also be based on co-creation (Følstad, 2008) as the main process for value creation to benefit society, the environment and the economy (Levén and Holmström, 2008). This means that an LL can act as a bridge between open innovation and user innovation within the QHM. To do this, LLs must involve the creative and innovative potential of users, so as to gain better insights into the possibilities, opportunities and restrictions of innovations (Schumacher and Feurstein, 2007). Therefore, LLs do not simply offer a network of

infrastructures and services, but are themselves a new way of dealing with user-driven innovation and sustainability challenges (Mulder, 2012). Indeed, users are increasingly being considered as co-producers when developing new services and new uses for devices and infrastructures (Pascu and van Lieshout, 2009). This means that LLs are moving away from the image of citizens as mere consumers of products and services (Arnkil et al., 2010), thus changing consumers' traditional role of observed subjects for testing products/services, into one of active co-creators of value (McPhee et al., 2013).

Although user engagement has now been recognized as a key element in LLs (Mulder et al., 2008) thus indicating a shift towards co-creation (Leminen et al., 2014), the literature emphasizes that user engagement could be further promoted by focusing on sustainability challenges and by stimulating users to express their opinions in order to obtain sustainable outcomes (Buhl et al., 2017). Furthermore, it has been observed that engaging users in the innovation process improves company performance across various industries (Edvardsson et al., 2010; Leminen, 2013). In particular, users contribute to speeding up development processes and to lowering costs (Leminen et al., 2015b). Users' knowledge too offers a valuable resource for innovation because it fosters understanding of real-life situations where products and services are involved (Poetz and Schreier, 2012; Rajala et al., 2013). Thus, LLs seems to be the latest stage of a continuum of versatile forms of open and of user innovation (Leminen et al., 2012).

Depending on the context, users could be companies, public bodies, professional users, consumers, employers, employees and, also, residents (Arnkil et al., 2010; Vecchio et al., 2017). Kaulio (1998) identified innovation/design for, with and by users within LLs from a theoretical perspective (Table 4). In this framework, users can either be perceived as subjects to be studied in a controlled laboratory environment or, can become equal-co-creators, adopting versatile roles (Leminen and Westerlund, 2012) in order to contribute to the innovation process of sustainable products and services.

3. Materials and methods

3.1. Case studies

In this paper, we have used a multiple case study methodology which is a qualitative form of inquiry (Birkner et al., 2017). It has enabled us to analyze processes which are poorly understood (Eisenhardt, 1989). A case study is considered a suitable strategy when addressing the "how" and "why" questions in exploratory research which studies a contemporary phenomenon (Eisenhardt,

Table 4
Users and innovation approaches in LLs (Source: Authors' elaboration of Kaulio, 1998).

Approach	Characteristic
Design for	an innovation approach where user involvement is limited to passive user feedback
Design with	a method mainly grounded on co-creation, as users and manufacturers work together in an iterative way
Design by	an innovation approach where users innovate themselves

1989; Yin, 1994). Moreover, a case study promotes deeper understanding of the complexity of an organization from an insider perspective, rather than being based merely on information gleaned from statistics (Ståhlbröst, 2013).

The case studies we have considered here are three LLs in three different European countries: CreaHUB Atelier di idee, which is supported by the University of Macerata in Italy; the Living Lab in Ageing and Long-Term Care, overseen by Maastricht University in the Netherlands; and InnovAge, which is managed by the Catholic University of Leuven in Belgium (Table 5). These LLs were selected because the universities, along with the University of Lisbon, are partners in a Horizon 2020 Twinning Programme entitled "Alhtour - Assisted Living technologies for the Health Tourism sector". The final goal of the project is to set-up a 'Health Tourism Living Lab' in the Lisbon area: health tourism has been identified as a key driver for territorial development.

The case studies all offer interesting points of reference because they bring together the common efforts of local stakeholders to address specific innovation challenges by engaging users. These case studies also provide insights that could be of use to LLs facing similar issues elsewhere. In particular, this analysis contributes to a better understanding of how the actors of a QHM participate in LL activities and of which practices can, and could, enhance user engagement in the innovation process.

3.2. Methodology and data collection

The study is based on both desk research and on an on-line survey. The methodology adopted is based on a five-stage approach followed by analysis of the data collected through questionnaires.

This stages, summarized in Fig. 1, are described below:

- Stage 1: an initial phase of brainstorming to glean insights from researchers and both public/private partners and stakeholders within the Alhtour project. To do this we performed brainstorming discussions with fellow-researchers and stakeholders in the Alhtour project and initiated informal conversations, calls and mail correspondence in English with representatives of the LLs. Through these informal conversations we gathered information from between three and five representatives of each Living Lab. Their positions in their respective LLs ranged from Ph.D. students who used the LL, to the Head of an Industrial Liaison Office, Scientific Coordinators, or Steering Committee members. The topics broached in these conversations included, for example, setting up an LL and the business models used for sustainable operations. This strategy was adopted in order to make the approach more flexible as well as to offer a way to gather personal thoughts (and opinions) regarding the challenges that have to be met when involving users in the innovation process. This method also allowed us to obtain valuable information because the representatives of LLs revealed experiences, reactions and concerns which would not have been available elsewhere (Creswell, 2013). As a result, this explorative stage made it possible to contextualize the study within both the European and the Lisbon frameworks. Information relating to contacts and procedures in each of the LLs studied was also gathered as well as regarding what steps could be taken to obtain detailed responses from their representatives.

- Stage 2: we performed a literature review of peer-reviewed scientific papers mainly using Elsevier's Scopus database. The analysis also included grey literature, such as policy documents and reports, drafted by national and European institutions engaged in the LL domain. We also collected documentation referring to strategic plans and operating standards from all partners in the Alhtour project and from representatives of the LLs. This was done to permit data triangulation (Blaikie, 2000) on research which focused on the questions of user-involvement, innovation and sustainability. As the main output, we have summarized the creation of LLs in Europe and the main EC initiatives as well as the main practices within these three domains, as featured in section 2.

- Stage 3: next, we developed and tested an on-line survey. After the structure had been aligned, we discussed which questions (and in which form) to include in each domain. This process was also always heavily supported by the domains present in the literature studied (stage 2). The survey was made up of a total of 77 mixed open and closed questions distributed among 15 sections. The sequence of open-ended and closed questions made it possible not only to evaluate respondents' personal understanding of, and attitude to, the issues dealt with, but also to obtain standardized, hence comparable, answers which were functional, useful, for broader comparisons (Selltiz et al., 1976). The impact of the size of the survey on the quality of the self-reported responses was considered in the survey design phase. Several of the open-ended questions were dependent on the values of previous answers, which meant that it was highly unlikely that one respondent needed to answer all the questions. The platform where the survey was deployed allowed respondents to break off and save their answers and then return to the survey later. The respondents selected were all participants in the Alhtour project, hence strongly motivated to provide quality responses. The first section of the survey concerned general information both about the LL and the overall environment in which was operating. Respondents were also invited to outline the characteristics of the partners and the framework of

Table 5
Case studies (Source: Authors' elaboration).

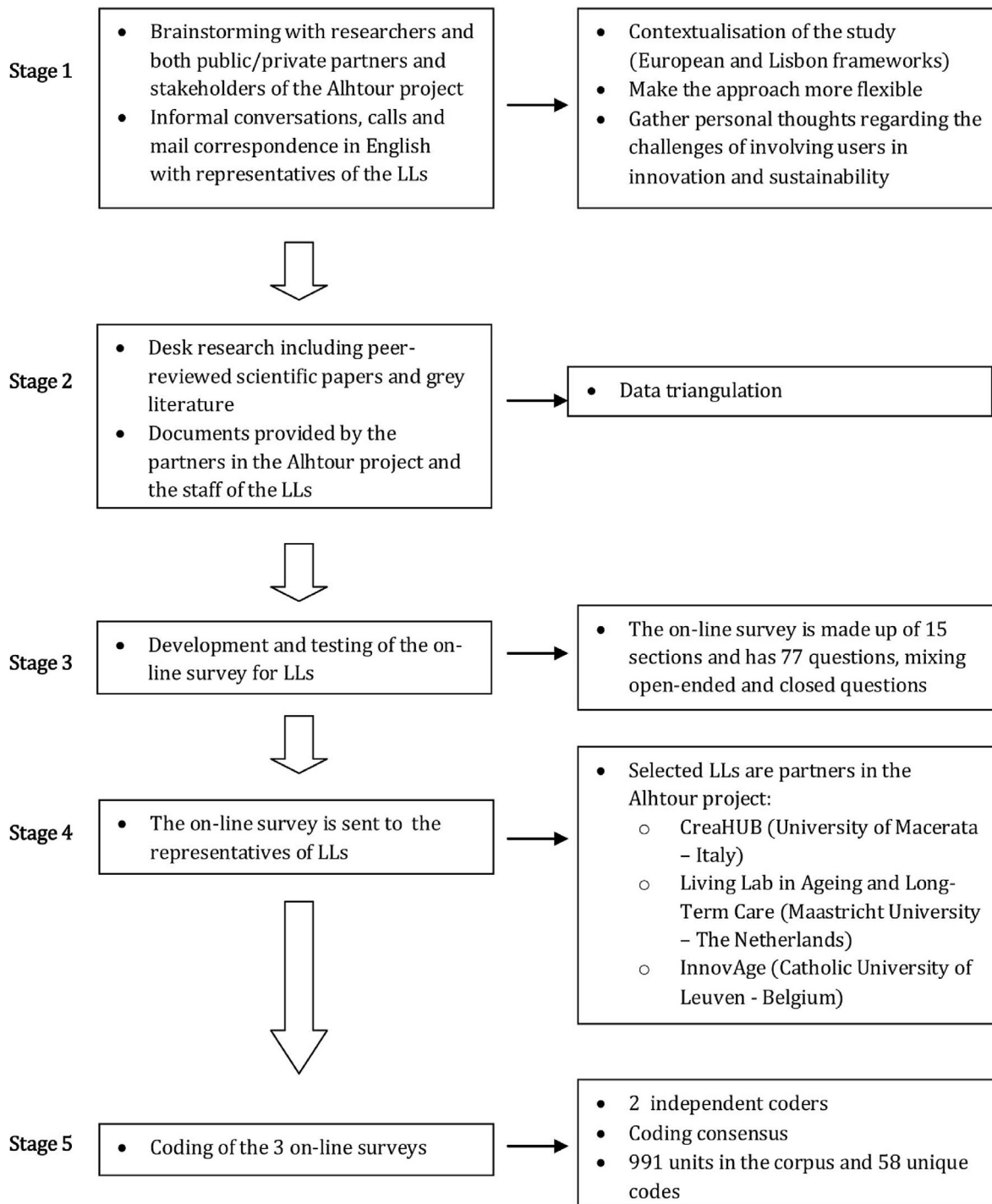| Living Lab	University	Country	Domain
CreaHUB, Atelier di idee	University of Macerata	Italy	Cultural and creative industries, including tourism
Living Lab in Ageing and Long-Term Care	University of Maastricht	The Netherlands	Health and ageing
InnovAge	Catholic University of Leuven	Belgium	Active ageing

Fig. 1. Flowchart of methodology (Source: Authors' elaboration).

the LL uniting them. The survey focused on the engagement and the contributions of users, universities, private stakeholders (companies) and governments both in, and to, the activities and the innovation processes within the LL. They were then asked to describe the governance and management of the LL. Respondents were invited to describe, explain and assess those practices that had been, and were being, developed by the LL, in order to foster innovation by first engaging and then increasingly involving users more and more. The survey ended with a set of questions focusing specifically on how LLs can or could

promote sustainability and how they were, and are, able to promote the UN SDGs. Ethical principles were observed when writing the survey (Groves et al., 2011).

- Stage 4: the survey was forwarded to representatives of the three LLs studied for compilation.
- Stage 5: the on-line survey was coded. We decided to base our analysis on coding (Auerbach and Silverstein, 2003) because a large amount of the information collected through the surveys was qualitative data. After a review of the literature, we decided to apply deductive coding (Fereday and Muir-Cochrane, 2006)

for our analysis. The codebook, drawn up after the literature review, is shown in Table 6. Two independent coders coded the three on-line surveys. Afterwards, both coders went over the coded corpus and reached a coding consensus. After consensus, 991 units in the corpus were coded by one of the 58 unique codes presented in Table 6. In the following section, we report the results related to each theme. The table groups the codes into the main themes in the codebook. For each main theme, there is a table showing the units for each LL and the sum of units of all LLs.

4. Results

The context of each LL clearly defines their Areas of activity. Table 7 reports the number of units coded in on this theme in each on-line survey. While both the LL InnovAge (Belgium) and the Living Lab in Ageing and Long-Term Care (the Netherlands) focus on the health domain, in particular on exploring ways of supporting long-term care, the CreaHUB Living Lab (Italy) has a different target area as it largely focuses on the cultural and market opportunities of the Marche Region. However, CreaHUB does address the question of "silver tourism", which falls under active ageing, thus approaching the domain from a different perspective.

Table 8 presents the number of units coded with LL Characteristics theme codes. As can be seen, the different topics of this theme were all explored, to some extent, explored. However it should be noted that methods, tools, and approaches were the main topics in most answers. It is clear that the CreaHUB LL focused more on business networks and different stakeholders than did the other two LLs.

As one would expect, the activities in each LL are connected to their area(s) of operation. The CreaHUB LL (IT) seeks not only to support new entrepreneurial initiatives but also to regenerate existing activities in both cultural and creative sectors. This is achieved through joint events, through training, and by supporting

Table 7
Coded units for the Areas theme (Source: Authors' elaboration).

Theme	Areas			
Codes	Active ageing	Culture and related sectors	Health	Tourism
Italy	1	19	2	1
Belgium	3	0	20	0
Netherlands	4	0	3	0
Total	8	19	25	1

local organizations in European projects. However, InnovAge (B), focuses on applied research and innovation activities, while Living Lab in Ageing and Long-Term Care (NL), focuses more on scientific research. The activities conducted reflect the orientation, the business models and the networks explored in each LL. CreaHUB wants to attract human and economic resources through participation in networks, and through calls for both public and private funding for projects. It is a member of several associations, both national and European. InnovAge too, participates in networks that help its members to get in touch with local, national and international stakeholders. Through such networks, members of these networks can benefit from collaborative research activities and private stakeholders are able to seek business opportunities for their new products and services. The network established by the Living Lab in Ageing and Long-Term Care helps and encourages its members to create synergies in business plan development, to exchange good practices, to implement cross-border collaboration and, to accelerate innovation. Such infrastructures are directly related to the supporting environment created by the LL. However, CreaHUB is a real-life environment, both the Belgian and the Dutch LLs are virtual environments, whereas CreaHUB also offers physical spaces for meetings, workshops, and even offices for start-ups. Indeed, these spaces are also used by the University of Macerata and by local associations.

The different approaches explored in all three of the LLs

Table 6
Themes and codes used to analyze the survey (Source: Authors' elaboration).

Theme	Code	Theme	Code
Areas	Active ageing	Living Lab Characteristics	Activities
	Culture and related sectors		Business models
	Health		Business networks
	Tourism		Challenges
Living Lab Location	Belgium		Infrastructure
	Italy		Methods, tools and approaches
	Netherlands		Outcomes
Innovation	Open innovation		Real-life environment
	Process		Stakeholders
	User-driven		Virtual environment
Operationalization	Governance	Context	Inclusivity
	Intellectual Property Rights (IPRs)		Networks
	Management		Policy
Roles	Enabler		User needs
	Provider	Outputs	Creativity
	Utilizer		Good practices
Costs	Cost-sharing		Knowledge production
	Innovation costs		Knowledge transfer
	Research costs		Local development
Activities	Co-creation		Transdisciplinarity
	Collaboration		User engagement
	Commercialization	Actors	Citizens
	Development		Government
	Prototyping		Industry
	Testing		University
	Validation	Sustainability	Activities
Sustainability	Strategy		Sponsors
	Initiative		Challenges
	Spin-off effect		Benefits

Table 8
Coded units for the LL Characteristics theme (Source: Authors' elaboration).

Theme	LL Characteristics									
Codes	Activities	Business models	Business networks	Infrastructure	Methods, tools, approaches	Outcomes	Real-life environment	Stakeholders	Virtual environment	Challenges
Italy	5	3	9	7	22	9	3	7	1	1
Belgium	2	3	2	4	25	9	5	4	1	2
Netherlands	3	1	3	3	26	4	0	3	1	0
Total	10	7	14	14	73	22	8	14	3	3

surveyed are summarized in Table 9. A variety of techniques are used for stakeholder engagement. CreaHUB collaborates with other LLs, organizing periodic meetings between its members to enrich, to expand, their competences. InnovAge promotes "concluding sessions", where project results are presented to everyone who has participated, both as a way of acknowledging their contributions, and of increasing the likelihood of acceptance and uptake of the results. The Living Lab in Ageing and Long-Term Care however, utilizes working groups in all projects involving researchers, professionals and elderly persons or their representatives.

The tools used specifically for dissemination of LLs results are summarized in Table 10.

Greater focus on co-creation and collaboration activities can be perceived from the survey answers. The number of units coded with codes from the theme "Activities" is presented in Table 11. Answers show that the activities in the earlier stages of the product or service development chain are more mature than those of the later stages, for example, testing or validation, or commercialization both for and after product development.

CreaHUB actively seeks collaboration with local actors and other LLs in the Marche Region. This collaboration focuses on promoting competencies in interdisciplinary cooperation/activities, teamworking, problem solving and analysis of entrepreneurial opportunities. Collaborating through CreaHUB also makes it easier for private and public entities to build partnerships and, by exploring the international contacts made available by the LL, stakeholders seeking business opportunities abroad can also benefit from the LL. InnovAge strongly emphases the co-creation concept, and states that collaboration, in particular that seeking to improve cooperation between primary, secondary and tertiary levels of care, is just one focus of their mission. However, collaboration for InnovAge means promoting the exchange of good practices, implementing cross-border collaboration, accelerating innovation, and creating synergies in business plan developments. Private stakeholders can also benefit from collaboration through support for ideation events, co-creation sessions, and through live testing. The InnovAge Living Lab does not seek to produce/market new products or services, which explains the absence of any such activities. For the Living Lab in Ageing and Long-Term Care, collaboration means facilitating, enabling, both the exchange of information between researchers

and staff, and between these latter and stakeholders, and vice versa. One example of such collaboration is that companies are able to send ideas to the LL technology working group thus, its members can thus decide whether or not they would like to participate in the project.

Table 12 displays the number of units coded with codes from the Innovation theme.

Both open innovation practices and user-driven innovation practices were extensively cited in answers given in the survey. CreaHUB promotes innovation practices by leveraging on R&D cooperation between private companies and universities, through both industrial and innovative Ph.D. courses. Also, it encourages informal relationships and interactions within the LL through collaborations between scholars and industry professionals and by support for business ideas from students. Support is given to creating multidisciplinary teams, in order to bring together researchers and both graduate and undergraduate students. This interaction also encourages applications for research grants, through LL networks that facilitate applications for national and European projects. Researchers promote relationships and interactions on a local scale and level by establishing relations with local public bodies and companies, students are also involved. The Lab supports training for young entrepreneurs, preferably students and researchers, by implementing ad hoc programs.

InnovAge adopts rather interesting innovation practices. It encourages the creation of joint teams to accelerate innovation, especially facilitation teams, that do daily follow-ups on projects. R&D cooperation between private companies - including multinationals - and universities is also promoted through key projects. Innovation is fostered by working with problem solving approaches through integrating customer and/or end-user perspectives, and by involving suppliers in new product design. Multidisciplinary teams, dedicated to innovation, are organized so as to promote relationships and interactions, through workshops and other events at the local level. The Lab also has a budgeting system for a team to oversee the correct application of open innovation principles.

The Living Lab in Ageing and Long-Term Care does not report the use of specific open innovation practices.

End-users are involved in innovation practices in many and diverse ways within the different LLs. In CreaHUB, users are co-

Table 9
Methods and tools employed in the LLs surveyed so as to foster user engagement in the innovation process (Source: Authors' elaboration).

Methods and tools	CreaHUB	InnovAge	Living Lab in Ageing and Long-Term Care
Workshops	Yes	Yes	Yes
Focus groups	Yes	Yes	Yes
Open discussion forums	No	No	Yes
Collaboration platforms	Yes	No	Yes
Idea submission systems	Yes	Yes	No
Conference calls	No	No	Yes
Online questionnaires	No	Yes	Yes
Face-to-face questionnaires	No	Yes	Yes
Laboratories on entrepreneurship and innovation	Yes	No	Yes
Business ideas contests	Yes	No	No

Table 10
Dissemination tools used in the LLs in the survey (Source: Authors' elaboration).

Dissemination tools	CreaHUB	InnovAge	Living Lab in Ageing and Long-Term Care
Web portal	Yes	Yes	Yes
Demonstrations and prototypes in test sessions	No	Yes	Yes
Demonstrations and prototypes provided to end-users	No	Yes	Yes
Demonstrations and prototypes available in the Living Lab	No	No	Yes
Social networks	Yes	No	Yes
Newsletters	Yes	Yes	Yes
Video or audio streaming	Yes	No	Yes

Table 11
Coded units for the Activities theme (Source: Authors' elaboration).

Theme	Activities						
Codes	Co-creation	Collaboration	Development	Testing	Validation	Commercialization	Prototyping
Italy	7	15	4	0	0	1	0
Belgium	12	12	1	7	2	2	3
Netherlands	3	7	3	3	0	0	4
Total	22	34	8	10	2	3	7

Table 12
Coded units for the Innovation theme (Source: Authors' elaboration).

Theme	Innovation		
Codes	Open Innovation	Process	User-driven
Italy	35	15	17
Belgium	38	11	31
Netherlands	32	2	29
Total	105	28	77

producers of marketable solutions that can be disseminated among entrepreneurs and policy makers. In this LL, users mostly take part in activities related to researching ideas for products or services. In InnovAge, end-users participate as idea generators (in ideation sessions), co-creators and live test subjects. They are also part of the LL network both formally, on "user days", and through their representatives on the steering committee. In InnovAge, end-users are also part of the activities related to, researching ideas for products or services, to developing those ideas, and to improving and refining products and services. In the Living Lab in Ageing and Long-Term Care, end-users can assume different roles. They may be activators (triggers of innovation), browsers (looking for innovative solutions), creators (conceptualizing ideas), developers (putting ideas into practice) and facilitators (enabling stakeholder collaboration). This LL is the one with the highest degree of involvement of end-users in innovation practices. End-users take part in researching ideas, developing ideas, designing products and in improving and refining products.

Table 13 shows the number of units coded with each of the codes of the Outputs theme. Most of the outputs mentioned address user engagement, which is a direct outcome of the activities, discussed previously, of local development and knowledge transfer.

The LLs offered different characterizations of the degree of involvement of end-users, which can be seen in Table 14, however, results are mostly uniform across all LLs. While it is reported that getting users interested is easy, all LLs agreed actually that involving them in a practical way is more difficult. Perhaps, as a consequence of that difficulty, all LLs report that it is also a challenge when showing users the benefits they can accrue from collaborating with the LL.

Benefits identified for local organizations go from developments

within the local economy, through an increase in the number of new enterprises and successful entrepreneurial initiatives, to increased internationalization of local start-ups. Benefits also include facilitating the matching of organizations with needs and talents with potential solutions, resulting in knowledge transfer to, and within, local communities and, more generally, from universities to markets and vice versa.

Topics relating to the LLs operations were not discussed in great detail in the survey answers, as can be seen from the figures in Table 15.

Each LL takes a different approach to Intellectual Property Rights (IPRs). In CreaHUB, IPRs are exclusively owned by private stakeholders, who can thus benefit commercially from the IPRs. At InnovAge, NDAs are signed whenever confidential information is shared with the steering committee and/or with participants at co-creation sessions. In the Living Lab in Ageing and Long-Term Care, IPRs issues are addressed for each specific project.

As regards governance and management, the LLs surveyed adopt different solutions. CreaHUB is managed by one scientific coordinator and one administrative coordinator; funding is public; and, there is no membership fee. In InnovAge, the coordinator reports to a steering committee where all partner organizations are represented. Funding is both public and private, but there is no membership fee. The Living Lab in Ageing and Long-Term Care is chaired by the University itself: the board is composed of representatives of partner organizations and funding is public, but there is also a membership fee.

Table 16 shows the number of units coded for the Actors theme. The participation of the different types of actors was discussed by all LLs, greater emphasis was laid on the University actor by the CreaHUB representative.

We enquired about the level of commitment of the different actors and how hard it is to maintain relationships with them. The answers of the three LLs are summarized in Table 17. Governments and public bodies generally look on the LLs as a support mechanism to implement practices in the LL's domain. This can take different forms, for example: promoting an entrepreneurial culture among students and researchers (CreaHUB); involving senior citizens in the innovation process (InnovAge); or looking for evidence-based knowledge (Living Lab in Ageing and Long-Term Care). On the other hand, private companies often regard the LLs as a means of meeting a different set of needs. CreaHUB reports that companies find both new business ideas, and talents to recruit. At InnovAge,

Table 13
Coded units for the Outputs theme (Source: Authors' elaboration).

Theme	Outputs						
Codes	Good practices	Knowledge production	Knowledge transfer	Local development	Transdisciplinarity	Users egagement	Creativity
Italy	2	2	14	20	10	15	5
Belgium	4	0	0	2	0	6	1
Netherlands	1	1	3	0	1	11	0
Total	7	3	17	22	11	32	6

Table 14
Difficulty of engaging end-users in the LLs surveyed (Source: Authors' elaboration).

	CreaHUB	InnovAge	Living Lab in Ageing and Long-Term Care
Interesting users	**Easy**	**Easy**	**Easy**
Involving users in practical ways	**Difficult**	**Difficult**	**Difficult**
Communicating concepts to users	**Easy**	**Difficult**	**Easy**
Showing the benefits to users	**Difficult**	**Difficult**	**Difficult**
Involving all users rather than specific groups	**Very difficult**	**Very difficult**	**Difficult**

Table 15
Coded units for the Operationalization theme (Source: Authors' elaboration).

Theme	Operationalization		
Codes	Governance	IPR	Management
Italy	2	6	6
Belgium	5	2	6
Netherlands	4	2	5
Total	11	10	17

Table 16
Coded units for the Actors theme (Source: Authors' elaboration).

Theme	Actors			
Codes	Citizens	Government	Industry	University
Italy	13	18	18	40
Belgium	9	14	11	14
Netherlands	11	13	8	9
Total	33	45	37	63

companies seek funding opportunities for innovation activities, business plan development and, for the involvement and collaboration of other stakeholders in ideation and in the development of products and services. In the Living Lab in Ageing and Long-Term Care, private companies can send their ideas to the technology working group and also collaborate on specific projects, but they are not formally part of the LL. For Universities, the LLs fulfill the need of helping to disseminate research at a more concrete and practical level, by interacting both with businesses and citizens (CreaHUB). They also offer support for recruitment and follow ups

Table 18
Coded units for the Roles theme (Source: Authors' elaboration).

Theme	Roles		
Codes	Enabler	Provider	User
Italy	4	2	5
Belgium	3	3	3
Netherlands	1	1	1
Total	8	6	9

with end-users (InnovAge) and to increase the social impact (Living Lab in Ageing and Long-Term Care).

We also investigated the 3 distinct roles (enabler, provider and user) and which actors assume, or have assumed, these roles in each LL. Table 18 shows the number of units coded for this theme.

As regards enablers, all three roles were, in some way or another, made possible by the joint efforts of local (provincial) organizations and the universities, but there are some minor differences: in CreaHUB, the university is still the main enabler, while the Province provides spaces for the university to work in. In InnovAge, two province-based organizations focusing on high-tech and education are the main enablers, but the latter is about to leave the consortium because education is not a focus of this LL. In the case of the Dutch Living Lab, not only the educational institutes and the government, but also long-term care providers were, and are, joint enablers.

As regards providers, in all three LLs, the universities are providers with roles assigned to undergraduate, graduate and Ph.D. candidates, researchers and professors. However, while in CreaHUB these are the only providers, in both the Belgian and Dutch LLs, health-related institutes and inter-university research centers also

Table 17
Engagement level and relationships with different actors in the LLs surveyed (Source: Authors' elaboration).

	CreaHUB	InnovAge	Living Lab in Ageing and Long-Term Care
Citizens, commitment	**Somewhat committed**	**Somewhat committed**	**Somewhat committed**
Citizens, keeping relationship	**Easy**	**Difficult**	**Easy**
Government, commitment	**Not committed**	**Somewhat committed**	**Very committed**
Government, keeping relationship	**Difficult**	**Easy**	**Easy**
Industry, commitment	**Somewhat committed**	**Somewhat committed**	**Do not take part**
Industry, keeping relationship	**Difficult**	**Difficult**	**Do not take part**
University, commitment	**Somewhat committed**	**Somewhat committed**	**Very committed**
University, keeping relationship	**Easy**	**Easy**	**Easy**

Table 19
Coded units for the Context theme (Source: Authors' elaboration).

Theme	Context			
Codes	Networks	Policy	User needs	Inclusivity
Italy	1	10	2	0
Belgium	2	12	0	0
Netherlands	1	0	1	2
Total	4	22	3	2

Table 20
Coded units for the Costs theme (Source: Authors' elaboration).

Theme	Costs		
Codes	Cost-sharing	Innovation costs	Research costs
Italy	3	0	3
Belgium	4	1	0
Netherlands	0	0	0
Total	7	1	3

play important roles. Both the Italian and the Belgian LLs are provider-driven, while the Living Lab in Ageing and Long-Term Care is not.

The three LLs show differences as regards their users. In CreaHUB, university spin-offs,[5] start-ups and scholars are the main users but private stakeholders also use it and take part in developing services. In InnovAge the main users are university-hospitals, as well as other communities and companies related to General Practitioners and primary care providers, and the citizens are, ultimately, those who benefit from the resulting products. Lastly, in the Living Lab in Ageing and Long-Term Care LL, long-term care providers, country-wide, and technology companies are the main users.

As regards context, as can be seen in Table 19, policy was the main subject discussed, except by the Dutch Living Lab representative. Nonetheless, it was possible to discern the extent to which, and how, the policies adopted are closely related to each, unique, regional context. CreaHUB mainly focuses on policies addressing recovery from economic and social challenges (some, but not all, the result of a recent earthquake-related crisis). Consequently, a lot of the regional policies adopted have been, and are, concerned with business initiatives, and with marketable and shared solutions. However, InnovAge policies focus on improving the effectiveness of the Care process and pathways (especially for the elderly) and on smart specialization strategies within the region, but not on commercializing new products.

When asked about meeting their costs, the three LLs were not particularly discursive as can be seen by the low number of units coded on this theme (Table 20). The main differences found, however, were related to cost-sharing: CreaHUB's costs are met by public grants and funding, student competitions and research grants. InnovAge's costs are met through both public and private funding. Very few references were made regarding how each LL applies for funding for research costs (Italy) or for innovation activities (Belgium). The Netherlands did not mention anything.

The final part of the survey focused on how LLs can contribute to the promotion of sustainability (see Table 21). The feedback from the respondents was diverse.

While sustainability is clearly a concern in the CreaHUB's LL, with its focus on cultural and creative industries, the same cannot be said of the other two LLs where sustainability is occasionally a spin-off effect of their activities. This difference is a direct result of the strategy followed by the bodies that run each LL. In the Italian Living Lab, the University of Macerata reports that sustainability is part of its strategic plan. The two other LLs do not have this strategic focus on sustainability (although the Belgian LL reports that sustainability was in their original mission statement). Nevertheless, they still declare outcomes with a sustainable effect on local activities, but only as a spin-off of the LL's operations. One important aspect of the Italian LL strategy for promoting sustainability and inclusion is the involvement of end-users linked to local and regional activities. CreaHUB also believe that different sponsors do

contribute to sustainability related efforts. University related actors (scholars and students at different levels) were identified as the most important stakeholders for their ability to move sustainability related projects forward. Companies mainly contribute to sustainability efforts by funding such projects. Civil society is engaged precisely because the LL functions as a means of integrating the end-users into the whole innovation process. Public administration also plays an important role by steering projects into those areas that require particular attention if they are to achieve sustainability and inclusion. The main challenges reported relate to the difficulty of establishing long-term partnerships, which are of paramount importance when dealing with sustainable activities. The LL's capacity and ability to facilitate interactions between all stakeholders is perceived as just one tool for overcoming this challenge.

As regards the specific SDGs addressed in this study, the Italian LL takes all four SDGs into account in their operations, while the other LLs report that they only partially implement SDGs 11.A and 17.16. It is interesting to note that CreaHUB discloses different levels of involvement of their stakeholders for different SDGs: university stakeholders are more active in 17.16 and 17.17; Civil society stakeholders in SDG 11.A; Companies in SDG 9.5; and Public Administration in SDGs 9.5 and 11.A.

For the other two LLs, sustainability seems more a "de facto" mission rather than a formally pursued goal.

5. Discussion

5.1. Context, tools, methods and approaches

The LLs surveyed are all exploring new ways of actively engaging users in the innovation process, but both the domains and the areas of action are very different. While the Italian LL focuses on entrepreneurship and real-life scenarios, the Belgian and Dutch LLs specialize in research and occupy virtual environments. This is also reflected in their level of promotion of sustainability, with the Italian LL including sustainability in their strategic goals. In both the Italian and the Belgian LLs, the areas of action and activities are closely related to, and interlinked with, Regional policies in their area. CreaHUB promotes and follows Regional policies that are seeking to help the area recover after recent earthquakes in the Marche Region. The activities undertaken and supported by the Belgian LL are coordinated through the Smart Specialization Strategy (S3) adopted by the Regional government of Leuven.

The characteristics of LLs, as defined in the literature (Tables 2 and 8), were also analyzed in the surveys. In all responses, the methods, tools and approaches adopted by the LLs, in order to involve users in the innovation process, were the most discussed issues. This confirms the issues the literature has often highlighted, i.e. the need for further analysis of the methods and practices adopted in LLs in order to ensure both knowledge sharing and effective interactions between QHM actors within LLs (Ballon and Schuurman, 2015; Friedman and Miles, 2006; Mainardes et al., 2011; Vecchio et al., 2017). Thus, this theme merits further investigation.

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[5] The university spinoff is defined as a company founded by academic staff to exploit university-generated knowledge in a profit making perspective.

Table 21
Coded units for the Sustainability theme (Source: Authors' elaboration).

Theme	Sustainability						
Codes	Strategy	Initiative	Spin-off effect	Activities	Sponsors	Challenges	Benefits
Italy	4	3	0	1	5	2	1
Belgium	3	0	2	0	0	0	0
Netherlands	0	0	0	0	0	0	0
Total	7	3	2	1	5	0	0

From a general point of view, the results show that the methods involved in the LLs are not affected by whether the labs are real or virtual environments. All three LLs studied use workshops and focus groups to engage users: citizens, entrepreneurs, firms, professionals or economic operators, whoever is involved. These focus groups are usually managed by professors, researchers and Ph.D. candidates. Much of the university staff engagement and the involvement of end-users and local stakeholders is helped by personal relationships, consolidated over time, through European projects and industrial/innovative Ph.D. courses. Tools related to new digital technologies, such as collaborative on-line platforms and calls for proposals to address local challenges, are widely used by all three LLs.

Laboratories on entrepreneurship and innovation are gradually becoming a common tool used by LL stakeholders. The characteristics of these laboratories, obviously, vary considerably, depending on the specific domain of each LL. However, laboratories usually consist of interdisciplinary courses to promote an entrepreneurial attitude among undergraduates, postgraduates, researchers and professionals. These laboratories also play a strategic role in enhancing knowledge transfer because they enable students to put into practice knowledge, competences and capacities, by interacting with stakeholders, who have other knowledge, and who are external to the university. On the other hand, competitions for innovative business ideas are being used more and more in the context of university LLs. This method is usually applied by private partners in non LL environments.

There are some differences in the methods used by all three LLs. For example: demos and prototypes are used for dissemination in the Belgian and Dutch LLs, but not in Italy. This could be because the CreaHUB LL focuses on activities that encourage the generation of new ideas and entrepreneurship, whereas the Dutch and Belgian LLs go beyond those ideas and encourage turning ideas into prototypes.

5.2. Activities, management and dissemination of results

Almost all the stakeholders in the three LLs have a good perception of co-creation and collaboration activities. Co-creation generally involves all the actors in the LL. Groups usually have at least one representative from each of these 4 domains: university, companies, government and users. However, collaboration itself is usually based on bilateral or trilateral relationships. In other words, there is more focus on the early stages of the co-creation of products and services rather than on the more "mature" stages of the development process, including commercialization. This could also be said of the Belgian case. Indeed, collaboration is a strong value in all 3 LLs: all focus on building partnerships and on promoting internationalization. Precisely how, and who with, differs: the Italian and Belgian LLs are more open to entities from outside the LL than is the Dutch LL, which latter focuses on cooperation between its members even though it does support research and/or ideas proposed by outside entities and, also, offers help with projects.

In terms of operationalization (IPRs and governance), these are

very LL specific: each LL operates in a very different way. This was predictable: each LL has different aims and approaches and, also, operates in a different funding context. Identifying which characteristics relate to which type of governance would be an arduous research task, one based on a far higher number, and a wider variety, of LL cases.

Costs, specific policies adopted, and the consequent activities undertaken, are also intrinsically related to context differences. Future work could be undertaken to understand not only how different policies impact on the way the different actors collaborate, but also to study, in depth, differences in the activities developed by each LL.

As well as organizing and managing activities, all three LLs focus on disseminating the results of co-creative and collaborative activities mainly through web portals, social networks and newsletters. These tools can stream short video contents to show demonstrations of services, prototypes and research outcomes, they are generally not expensive and, they allow LLs to reach a wider audience. Indeed, digital tools overcome the limit of disseminating scientific outputs only to those users who are, or were, directly involved in the innovation process which led to the prototype.

5.3. Innovation practices and user engagement

As regards innovation practices, these are very specific in each case. The CreaHUB LL organizes industrial and innovative Ph.D. courses, supports student ideas and includes undergraduate students in multidisciplinary research teams. The InnovAge LL promotes teams doing daily follow-ups, appoints an innovation manager, and includes customers and end-users in program-solving activities. However, all the 3 LLs surveyed adopt these three innovation practices: cooperation between private companies and universities; the use and constitution of multidisciplinary teams; and, a focus on securing research grants.

Idea generation is involved in all three LLs innovation practices for end-user involvement. However, both the Belgian and the Dutch cases go beyond that: the former encourages and facilitates co-creating and testing, while the latter goes even further, and also supports both final product design and development. Despite these differences, there were no discernible differences when all three LL representatives were asked about the difficulty of involving users (Table 14), indeed, only the Belgian LL reported an even greater difficulty: that of communicating concepts to users.

It is easy to attract users' interest in the activities carried out by LLs. Digital tools play a strategic role in this because they reach a wider audience by disseminating research outputs and streaming demonstrations of prototypes and services. On the other hand, involving users, and encouraging them to play an active role within LL initiatives is far more challenging. It is often difficult to convince users of the advantages deriving from collaborating with LL stakeholders. Indeed, the focus and specialization of the LL has an impact and while users may be willing to contribute to the generation and development of tourism and cultural products and

services, they are often reluctant to actively participate in the domains of health, long-term care, and active ageing in the innovation process. This is (often) because of ethical aspects or issues of personal confidentiality: such domains directly involving personal data from users who, for example, may not always be willing to disclose details about their health.

5.4. Living Labs as facilitators to foster innovation and sustainability

Living Labs try to engage users through active involvement and dissemination of information regarding innovation, so it is worth considering the role played by the efficient and effective collaborative strategies adopted by the LL and its stakeholders. The Dutch Living Lab in Ageing and Long-Term Care is the LL that reports the least difficulty in maintaining communication with the various actors involved, but it is also the only LL in the study that does not collaborate directly with industry, which is the ambient that the other two LLs consider to be the most problematic area as regards maintaining communication.

The three LLs also have diverse collaborative relations, active or passive support, from their respective governments. The fact that the Dutch LL does not involve a big player like industry, but instead receives direct support from the government, might contribute to its lower communication problems. However, the Belgian LL finds it more difficult to maintain relationships with citizens.

As regards the contribution made by the actors to the LLs, local governments and universities are those most involved in the launch and management of the LLs. Governments both offer support mechanisms and contribute to implementing the practices that fall within the LLs domain by providing economic and human resources, as well as physical structures (offices, meeting spaces and laboratories). Companies, however, usually support the development of new business ideas and can also enhance LL initiatives by selecting and recruiting talents, such as graduates and young researchers, from within the local university. Furthermore, companies can finance innovative prototypes, as well as offer opportunities for national and international collaborations to develop products and services.

As regards the contribution made by universities, the LL provides researchers, tools and spaces, both real and virtual, to disseminate research outcomes at a more concrete level through interaction with users, companies and local authorities. Universities also contribute to LL initiatives by training young talents and providing technical support to implement user engagement strategies and innovation. In other words, the LL is a platform which allows the university to increase its impact at a local level, fulfilling and broadening its Third Mission as well.

The main difference between actors lies in who uses an LL, so the difference here is probably merely a reflection of the activities and goals of each LL.

The LLs reported completely different assessments of the role that sustainability plays as a driving factor in their LL activities. While for CreaHUB sustainability is part of their strategic plan, the other LLs may have sustainable outcomes but only as spin-off effects of their planned activities, not as a goal. Consequently, the analysis of the contribution an LL can make to promoting sustainable outcomes is mostly supported by data from the Italian LL. The main challenge reported by CreaHUB as regards promotion of sustainable outcomes was the difficulty of engaging stakeholders in long-term partnerships. The LL was, and is, seen as fundamental tool for addressing this challenge. By facilitating interaction between the different stakeholders, an LL contributes to improving their mutual understanding and goals, and also enables long-term relationships to develop which are more likely to support, and

achieve, sustainable outcomes. It is also important to notice that the different stakeholders of an LL reveal different interests and motivations in their approach to different SDGs.

These results confirm the findings of a recent review by McCrory et al. (2020) according to which LLs posit a triadic understanding based on different contexts, processes and ways of organizing innovation. In this framework, sustainability is not only a normative definition, but also a dynamic interpretation, one which should encourage reflection on the design and set-up of sustainability-oriented LLs. Furthermore, the main findings discussed in this paper are in line with the results of previous studies (Compagnucci and Spigarelli, 2020; Rodrigues and Franco, 2018) which suggest strengthening the analysis of the role of LLs as facilitators. In particular, LLs should be considered as a connection point for local stakeholders, especially government, start-ups and university spin-offs, to contribute to economic and social development and sustainability.

To sum up, Fig. 2 summarizes the key messages and their implications that have emerged from analysis of the data collected. We have found that LLs can support interactions between all actors in the QHM (RQ1) through a multiplicity of methods. While there are no standard solutions, it is clear that digital tools are a decisive factor for reaching out to all actors. The contextualization of the LL activities in the scope of regional policies has also shown to contribute to increasing the outreach of the LL. However, although we found that LLs can reach out to all actors in the QHM, it was also clear that actors are not always involved in the same way in different LL activities. Nevertheless, it was interesting to find that whether the LL was deployed in a real or a virtual environment had no effect on its ability to reach its stakeholders. However, digital tools were found to be particularly important for dissemination activities and, therefore, future LLs would do well to invest in exploiting them. This study was conducted before the start of the COVID-19 pandemic, and it could safely be argued that this is an even more important recommendation now.

On the other hand, within the samples scope, it could be seen that LLs focus on their stakeholders' contributions (RQ2) especially in the early stages of product and service design. LLs still face difficulties when trying to persuade end-users to play a more active role in collaboration on, for example, co-design. Nevertheless, focusing on promoting entrepreneurship and innovation activities does offer promising strategy for involving, and reaping the rewards of involving different actors. The actors of the THM can also be motivated through the realization of benefits stemming from knowledge transfer that can be promoted by an LL. However, the fourth actor in the QHM is more difficult to attract through these mechanisms. Dissemination efforts through the demonstration of LL results have been successful in promoting the involvement of representatives from civil society, but those efforts have a limited scope, in that they are not sufficient to attract those representatives to design activities. Further studies and experience are needed to better understand which mechanisms would promote their participation in these stages of LL activities.

Sustainable development goals (RQ3) are not always seen as priorities for LLs. Nonetheless, focusing on knowledge transfer and, especially, on creating long-term relationships between the actors, does make these goals more attainable. Even though we could not find instances of steps taken specifically by the LLs in our study to address sustainable development goals, LLs are able to align private action, public policy, societal interests and research efforts for the common good. By connecting the actors in a QHM, an LL is extremely well equipped to assess the impact of each SDG on the context in which it is deployed. It also has the tools to manage discussions between stakeholder representatives and, not only to promote the SDGs across the community, but also to engage each
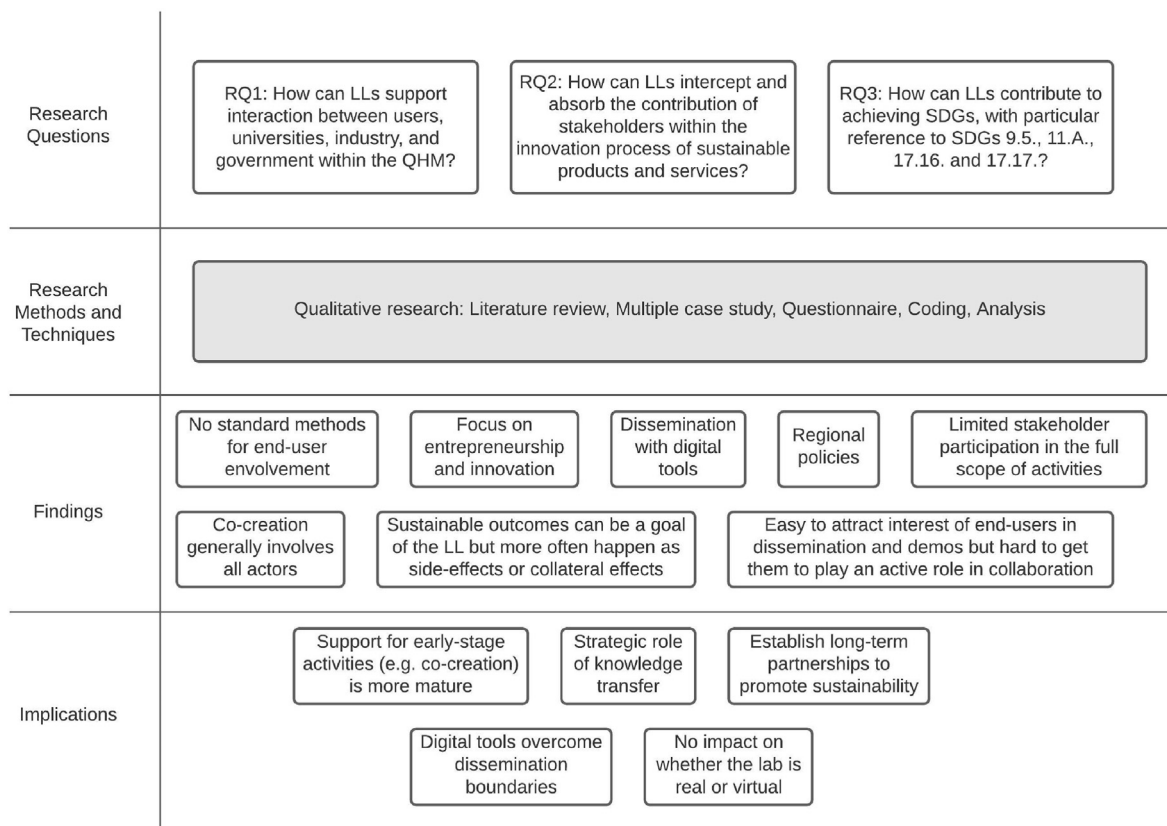
Fig. 2. Summary of main findings and implications (Source: Authors' elaboration).

actor in the pursuit of these goals. LLs should also be responsible for reporting on the progress made towards each goal and so reap the benefits from increased awareness throughout the LL.

6. Conclusions

This paper seeks to contribute to the understanding of how LLs can foster user engagement in the shift from a THM for innovation, towards a QHM with its intertwined university - industry - government - civil society relationships. We have also sought to understand how, and to what extent, this transition can help to achieve more sustainable growth at the local level. We have analyzed both how LLs can support the interaction between users, universities, industries and government, and how LLs can intercept, and absorb, user's contributions to the innovation process.

The stakeholders of all the three LLs studied (in Italy, the Netherlands and Belgium) have a good perception of co-creation and of collaboration activities. These LLs are exploring new methods and approaches to actively engage users in the innovation process in different areas (health, long-term care, active ageing, culture and related sectors) and have met with differing degrees of success in a wide variety of areas. These 3 LLs all focus on testing and developing new tools for disseminating research information, streaming demonstrations of prototypes, and convincing users of the advantages deriving from collaboration with LLs.

It should be noted that in all the three LLs studied here, the launch, development and management of the innovation process are mainly based on promoting local, national and international networks. These LL networks make it possible to contact private and public actors and, also, to encourage participation in European and national funding programs. Furthermore, these networks all

seek to create opportunities for developing new products and services by involving users from the outset, at the idea generation stage, rather than involving them only at the testing and validation stages. These 3 LL networks also encourage the exchange of good practices and help accelerate innovation among, and between, both stakeholders and users. The innovation processes are also driven by multidisciplinary research teams in which users are involved as active players. In all cases, funding is essential for LL operations: for applied research grants, industrial and innovative doctorates, and for the physical structures provided by local governments.

In terms of user engagement, the LL cases studied here have revealed that it is not particularly difficult to attract user interest in the LLs' activities. Digital tools play a strategic role here, because they facilitate communication with a wider audience and so help disseminate research outputs by streaming demonstrations of prototypes and services. Nonetheless, LLs do often find it difficult both to encourage users to take a more active role in the innovation process and to convince them of the advantages deriving from collaboration with other LL stakeholders. This question deserves more in-depth attention and research as it could contribute to further understanding of how LLs could and should interact with users.

The role of LLs in promoting sustainable activities was different in each of the cases studied. However, the need to have sustainability as a strategic factor in an LL emerged from the reports of all three LLs: the LL that explicitly considers sustainability, obviously promotes projects that address it. The other two do have sustainable outcomes, but these occur as spin-offs. Thus SDGs 9.5., 11.A., 17.16. and 17.17 are directly or indirectly promoted in all our cases. Respondents reported that the biggest advantage reported of having an LL supporting sustainable outcomes is its subsequent ability

to foster long-term partnerships between stakeholders: a paramount factor in increasing the likelihood that sustainable projects will be successful. In this case, companies mainly contribute to sustainable goals both by funding research projects and funding, or employing, young researchers.

As for the limitations of the study, this paper is based on a small sample, 3 European LLs, which are adopting co-creative approaches, and integrating research and innovation processes. Indeed, more cases (from different geographical areas and involved in different thematic activities) are required to better assess the real impact of LLs on innovation and sustainability. The practical challenges discussed here, especially those relating to innovation practices and user engagement, should be further investigated with particular attention paid to the possible domains of the LLs which could offer results based on the specificity of the context. Therefore, further research should consider a wider set of LLs focused on an array of domains, in order to analyze the specific tools and approaches adopted to engage users in the process of innovation in sustainable products and services.

Also, given our methodological approach, questionnaires, we cannot extrapolate truly in-depth findings, something we could do by, for example, using semi-structured face-to-face interviews. Hence, deeper, or more descriptive findings must wait until other methods, such as interviews, are used. On the other hand, the insights gained should be further tested by adopting quantitative approaches to extensive samples of LLs so as to open up new paths for future analysis on this topic.

In conclusion, a clearly defined LL model did not emerge from the analysis. Indeed, there is often a combination of innovative approaches which are managed by the users themselves, with users, or for users. Sometimes, user involvement is limited to passive feedback, sometimes it is based on active co-creation and involves users and LL stakeholders working together interactively. However, LLs are not merely a network of infrastructures and services, rather they offer a new way of managing innovation and sustainability through the active involvement of users. LLs promote the role of users as value co-creators within a QHM for innovation. Users are not relegated to a passive role of mere consumers of products and services or mere subjects on which to test products and services.

CRediT authorship contribution statement

Lorenzo Compagnucci: Conceptualization, Methodology, Investigation, Writing - original draft, Writing - review & editing. **Francesca Spigarelli:** Conceptualization, Methodology, Investigation, Writing - original draft, Writing - review & editing. **José Coelho:** Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing - review & editing. **Carlos Duarte:** Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing - review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

Appendix A. Supplementary data

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