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SIRENE

SOCIAL INNOVATION RESPONSIVE ENVIRONMENTS NETWORK

D1.1 State-of-the-art Solutions for Eco-friendly Inclusive Environments

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Integration of social innovation actors in innovation ecosystems

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EXECUTIVE SUMMARY

This document is deliverable D1.1 of the Social Innovation Responsive Environments Network (SIRENE) project, which provides desk research on state-of-the-art methods, standards, and guidelines in the development of responsive inclusive eco-friendly environments. The goal of this report is to provide a solid theoretical background on which the SIRENE framework can be built, to ensure its effectiveness and sustainability.

Because of the demographic ageing of our society, smart housing solutions are becoming increasingly important to enable the independence of frail older people and individuals with impairments, and to ensure their continued involvement in the community and lessen the growing pressure on our healthcare systems. The current housing stock is mostly unequipped to facilitate this growing group of people, and the development of smart buildings and cities is slow-going due to a lack of standards and regulations that can boost investment. The SIRENE project aims to develop a social innovation framework and tools for the creation and nurturing of ecosystems in the area of Smart Healthy Age-Friendly Environments (SHAFE) that support social entrepreneurs to gain awareness on the topic and grant access to the relevant networks and funding opportunities, enabling innovation investments that meet the changing needs of citizens across their lifetime.

This state-of-the-art review contains an introduction to the topic and an elaboration of different concepts relating to responsive environments. An overview is given of the existing knowledge production modes and innovation frameworks, as well as a review of good practices, an ethical assessment, and a gap analysis of current R&I initiatives. The last chapter contains the conclusions and recommendations for building the SIRENE framework and will present the innovation model that will be used during the development thereof.

To emphasise collaboration between ecosystems, a new model was conceptualised: the Transnational Local-sphere Model. This model puts the focus on stakeholders, organisations, and underrepresented entities, is user-centred by using a bottom-up approach, includes (trans)national collaboration and competition, is *glocal* by integrating global and local ecosystems, and involves civic society, through the media and the public. By using the Transnational Local-sphere model, the SIRENE solution will connect existing local social innovation ecosystems and create a trans-sector network of stakeholders to ensure an accessible and sustainable result for its users.

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SYMBOLS, ABBREVIATIONS AND ACRONYMS

AHA	Active Healthy Ageing
CUA	Costs Utility Analysis
D	Deliverable
DoA	Description of Action
ERF-AFH	European Reference Framework on Smart Age-Friendly Housing
EU	European Union
GDPR	General Data Protection Regulation
GPB	Good Practices Blueprint
IoT	Internet of Things
KBE	Knowledge-based Economies
R&I	Research and Innovation
RDI	Research, Development, and Innovation
RRI	Responsible Research and Innovation
SHAFE	Smart Healthy Age-Friendly Environments
SI	Social Innovation
SIRENE	Social Innovation Responsive Environments Network
SSCC-CG	Smart and Sustainable Cities and Communities Coordination Group
T	Task
TIE	Thematic Innovation Ecosystem
WP	Work-Package

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1 INTRODUCTION

1.1 Background and aim

In 2016 the United Nations introduced the Sustainable Development Goals [1], which outline priorities such as good health and wellbeing, and the importance of sustainable cities, communities, industry, innovation, and infrastructure as the next baseline for guaranteeing a better future for the population. Due to the demographic change of the European population the health and wellbeing of the future generation are at risk. Population ageing has consequences for many aspects of society and daily life: social aspects (like work and employment, amount of leisure, safety, family ties and informal care), economic aspects (like pensions and poverty, products and services, old age-dependency ratio, health care costs) and environmental aspects (like quality of local environments, cultural heritage, land use, housing). The longer people manage to stay healthy (and, where appropriate, play a big part in managing their own health and lifestyles), live in their own homes and communities, and remain active in economic and social life, the better it serves their wellbeing and quality of life. In addition, they remain net contributors (e.g., as workers and consumers) and less time, money and effort are needed in social and health care provision through formal or informal channels and means.

Suitable living environments are therefore one of the key elements of making the Sustainable Development Goals more realisable. However, this requires a change in how our living environments are constructed and organised. Buildings need to be more versatile, easy to enter, easy to navigate in and around, to better meet the changing needs of occupants over their lifetimes, be capable of easy and cost-effective adaptation, and of course ensure they are environmentally friendly [2]. Europe needs a broad quantity of these responsive, inclusive, eco-friendly living environments that will enable citizens – in particular older people and those who are frail, have impairments or disabling illnesses – to continue to live in their own homes. The current housing stock is mostly unequipped to facilitate these needs, and the development of smart buildings and cities is slow-going due to a lack of standards, regulations, and collaborative networks. Investments in smart living solutions by construction and IT companies, homeowners, and households themselves, are needed urgently to upgrade the current housing stock into appropriate smart living environments for ageing well. This is an exciting area for investments, especially after the COVID-19 pandemic situation, which would much benefit from a strong alignment between social entrepreneurs and innovation ecosystems. The stimulation and fostering of these innovation collaborations is the main goal of the SIRENE project. The aim of deliverable D1.1 is to provide a solid theoretical background on which the SIRENE framework can be built, to ensure its effectiveness and sustainability.

1.2 Synergies with other tasks and deliverables

SIRENE will develop and sustain a social innovation framework and tools for the creation and nurturing of ecosystems in the area of Smart Healthy Age-Friendly Environments (with a special focus on eco-friendly responsive housing) that support social entrepreneurs to gain awareness on the topic and grant access to the relevant constellation of actors and to funding opportunities, enabling innovation investments that meet the changing needs of citizens across their 9lifetime. The project ambition is to facilitate an EU-wide network, connecting different actors and perspectives under a common theme, to test and implement SHAFE innovations for

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a stronger directionality towards the twin transition, with economic, social and environmental sustainability, including at a local level and in rural areas. The SIRENE SI framework will consist of:

- a **manual** for innovation actors on SI methods and concepts, especially focused on those that can be used to promote responsive, inclusive, eco-friendly environments;
- a **capacity-building framework** for social entrepreneurs especially focused on funding opportunities and securing investment;
- a **hands-on toolkit** of networking and learning exchange initiatives;
- a **sustainability strategy** that includes examples of SHAFE business models and practical ideas for SI investments on SHAFE;
- a **blueprint of good practices** and SI initiatives around SHAFE for benchmark and future twinning.

The goal of Work-Package 1 (WP1) – Building the Social Innovation Framework, of which this desk research is a part, is to promote social innovation implementation and investments in eco-friendly inclusive environments, by developing a robust framework and tools for the construction and expansion of social innovation ecosystems. This framework will be built by drawing together state-of-the-art knowledge and good practices, which will be described in this desk research. WP1 will also condense the collected data in a cloud-based data repository and will envision a Good Practices Blueprint (GPB) that will be used for developing a proof of concept and validation of a user-oriented, clear, and accessible infographic for the European social innovation framework delivered in WP3 – Support measures towards stakeholders. The co-creation network that will be built in WP2 – Activating the co-creation network – will be used to feed the building of the social innovation framework, approach the ethical impacts, and validate the final version. The ethical assessment of this state-of-the-art review will be incorporated into the Gender and ethics management plan and report in WP5 – Project Management.

1.3 Methodology

To reach the above-mentioned goals, this desk research will create a review of state-of-the-art solutions and good practices for social innovation ecosystems that can be leveraged for the area of responsive, inclusive eco-friendly environments. In addition, privacy and other ethical issues regarding the building of the social innovation (SI) framework will be identified and handled, and an ethical assessment will be undertaken. The ethical assessment will deliver the ethical requirements and needs that must be considered when building and working with the framework.

At the same time experts from 27 EU countries and two additional international experts were identified and involved in the so-called Expert Hub launched in February 2023. The Expert hub hosts regular themed sessions with stakeholders and users from different countries and backgrounds. With this methodology, a new social innovation framework and its corresponding tools will be created, which will be expert-proven and validated by different stakeholders of all countries in Europe, for smart, inclusive, and eco-friendly environments. These outputs will be ready for large-scale adoption.

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1.4 Structure of the deliverable

First the concept of responsive, inclusive, and eco-friendly environments will be discussed and explained, along with innovative practices, and standards and guidelines. Then, an overview will be given of current SI frameworks and state-of-the-art knowledge and good practices, including those from the SHAFE Network and COST Action 19136 NET4Age-Friendly, the CSA Homes4Life, the Thematic Innovation Ecosystem on Housing and Health, the European Reference Framework on Smart Age-Friendly Housing, the Green Deal, and pilots and initiatives that relate to RRI and Social Innovation practices. In chapter 4, a gap analysis and mapping of strengths of social innovation frameworks around responsive, inclusive, and eco-friendly environments will be given. Lastly, the ethical assessment will be discussed in chapter 5, followed by the conclusions and recommendations for building the Social Innovation Framework in chapter 6.

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2 Social innovation ecosystems

2.1 Introduction to the topic

"**Social innovation"** (Figure 1) refers to the design and implementation of new solutions that imply conceptual, process, product, or organisational change, which ultimately aim to improve the welfare and wellbeing of individuals and communities. Many initiatives undertaken by the social economy and by the civil society have proven to be innovative in dealing with socio-economic and environmental problems while contributing to economic development" [3]. As such, social innovation is a broad concept, encompassing a wide range of disciplines, methodologies, and interactions.

It can be difficult to envision what social innovation looks like in our daily lives; for many the word 'innovation' is predominantly linked to technological advancements, while in reality it encompasses so much more. In an article from 2016 [4], the concept of social innovation was subdivided into ten categories, in order to shed more light on the complexity of the topic. The categories are as followed:

- Socio-analytical innovation (e.g., citizen science)
- Socio-cultural innovation (e.g., a change in tradition)
- Socio-ecological innovation (e.g., the Stockholm Resilience Centre)
- Socio-economic innovation (e.g., inclusive business/value chains)
- Socio-ethical innovation (e.g., corporate social responsibility)
- Socio-ideological innovation (e.g., the 16th/17th century Reformation)
- Socio-juridical innovation (e.g., the introduction of a citizen jury)
- Socio-organisational innovation (e.g., the 'New way of working')
- Socio-political innovation (e.g., more citizen involvement through referenda)
- Socio-technical innovation (e.g., use of social media)

It is important to highlight that social innovation is not limited to these categories and new types of social innovation will likely continue to emerge. In fact, this typology was made to prevent the limitation of the concept of SI and to broaden our understanding of it. These examples, therefore, give a good insight into what shapes and forms social innovation can take, besides the more well-known technological advancements.

Figure 1. Artistic impression of 'social innovation' (www.freepik.com [5]).

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Social innovation ecosystems are environments in which social innovations emerge. However, the concept is still poorly defined and has not been implemented on a larger scale. It requires a multi-sectoral perspective, including actor-centred concepts, governance models, supportive infrastructures, and legal and cultural norms [6]. The current entrepreneurial ecosystem is profit-oriented and is unsuitable for many of the challenges that our society faces today. Social innovators have indicated they need long-term socio-political focus, education on societal problems, simplified financial support, more open-minded and broader cultural perspectives, and assistance in public outreach, among other things [7]. To fully tap the potential of social innovation, an enabling policy framework is needed to support public, non-profit and private actors to co-construct and implement socially innovative solutions and thereby contribute to addressing socio-economic issues, build stronger territorial resilience and better respond to future shocks [3].

Nonetheless, the amount of territory-specific **small-scale social innovation ecosystems** that operate on a local level has been steadily growing over the years. Most of these ecosystems are composed of up to ten organisations. The benefit of such local biomes is that they have a closer interaction with the needs and wants of the population and can therefore provide a considerable social value to the public. Yet research has indicated that only 28% of results are exploited. This is due to a lack of a solid multi-stakeholder approach in which policymakers, research organisations, and non-profit organisation work together to create better adoptable and more sustainable solutions [8].

2.2 Overview of existing and emerging social innovation frameworks in Europe and beyond

This chapter gives a concise description of innovation models and frameworks that can be used as a basis for the creation of SI initiatives, networks, and ecosystems. The search was limited to knowledge production modes and helix-frameworks, because to learn about social innovation in the best way is to relate it to social sciences in which knowledge production modes and helix-frameworks are the most well-known, best used and well-established innovation models.

2.2.1 Knowledge production modes

As the name suggests, 'knowledge production modes' are methodologies to produce (scientific) knowledge. Currently, three different modes have been conceptualised. Mode 1 and 2 were first described by Michael Gibbons *et al.* in 1994 [9]. **Mode 1** is a linear model of innovation (Figure 2) based on traditional academic knowledge development within separated disciplines, using a hierarchical structure of established peers to ensure quality. In this mode, the acquired knowledge does not need to have any practical applications and is not guided by social needs or economic interests. **Mode 2** on the other hand, is a non-linear innovation model (Figure 2), which favours practical application, trans-disciplinarity, non-hierarchical organisation, social accountability, and reflexivity [10; 11]. The mode 2 model promotes the creation of transdisciplinary collaborations, where scientists are more reflexive and use different quality standards [12]. In their book Gibbons *et al.* advocate for a shift from mode 1 to mode 2 [9], but other researchers indicate that mode 2 is not a new concept and is in essence the origin of scientific research, while mode 1 is a theoretical construct and does not accurately describe the current academic model, since multi-disciplinary research and applied sciences are common

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elements in academia [13]. Others have accused the mode 2 framework of being a political ideology [14]. Mode 2, in the way it was described by Gibbons *et al,* was therefore never universally accepted.

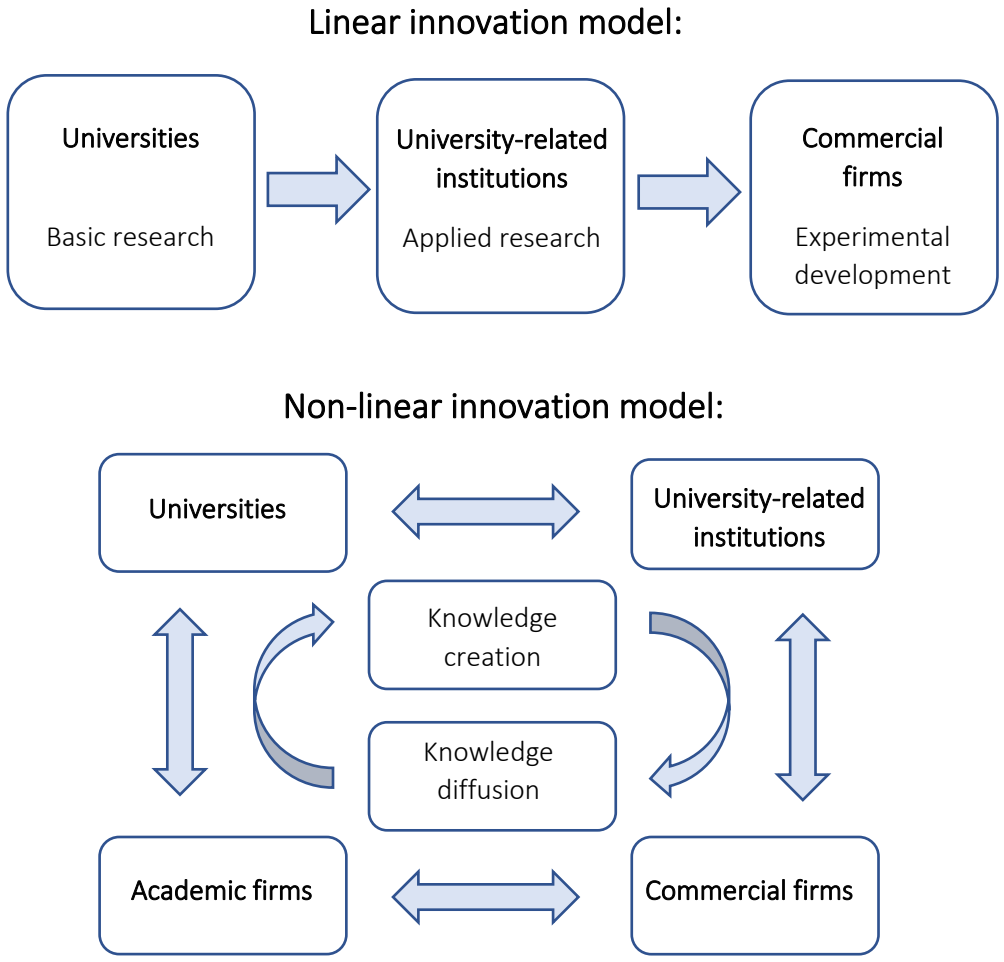

Figure 2. Representation of linear and non-linear innovation models (adapted from Carayannis & Campbell 2009 [16, page 211]).

Mode 3 was proposed by Carayannis and Campbell in 2006 [15] as a response to the increasing need for both globalising and localising (*glocalising*) innovations. Mode 3 consists of innovation networks and knowledge clusters, bringing together socio-economic, political, technological, and cultural aspects, co-creating a 21st Century Innovation Ecosystem (Figure 3) [16]. In mode 3 linear and non-linear innovation models are combined, building on modes 1 and 2, and the quadruple helix framework (see §2.2.3). Mode 3 emphasises the co-evolution and integration of these different innovation paradigms, seeking a balance between cooperation and competition ('*co-opetition*'). This way a fractal knowledge and innovation ecosystem is created that is better equipped to handle modern societal problems by "being endowed with mutually complementary and reinforcing as well as dynamically co-evolving, co-specialising and co-opeting, diverse and heterogeneous configurations of knowledge creation, diffusion and use" [16, page 223].

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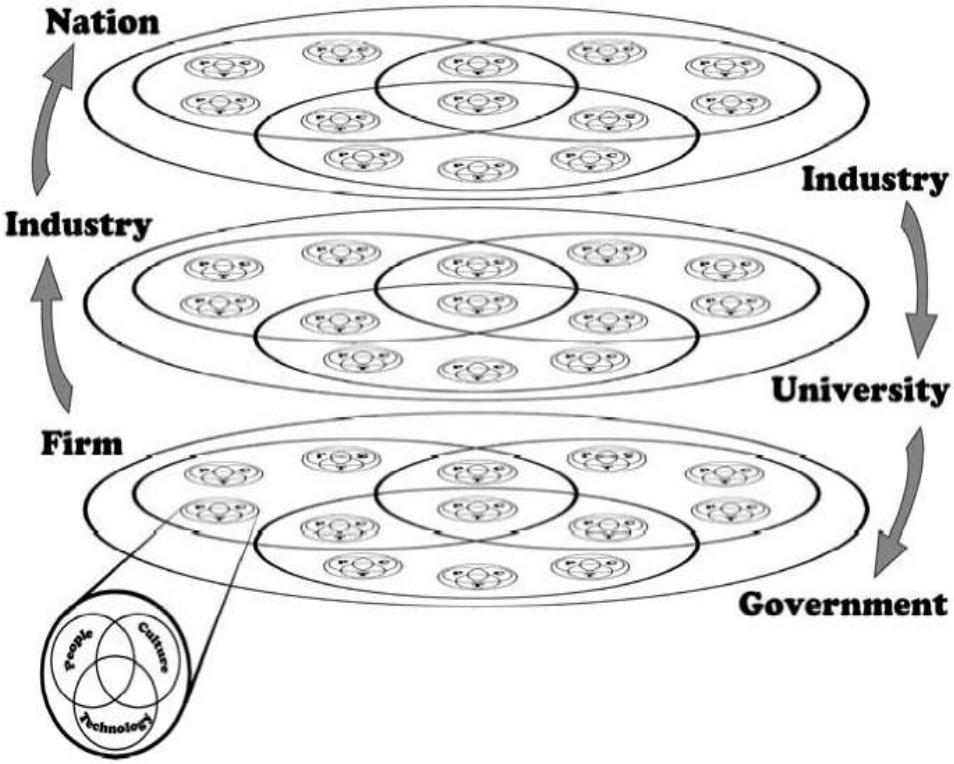

Figure 3. Visualisation of the 21st century fractal innovation system (taken from Carayannis and Campbell in 2009 [13, page 223]).

2.2.2 The Triple-helix framework

The triple-helix innovation model was first described by Etzkowitz and Leydesdorff in 1995 [17]. The framework consists of three overlapping institutional spheres, symbolising the government, academia, and the industry (Figure 4). The overlapping regions represent hybrid organisations, like university spin-off firms, government laboratories, and tri-lateral initiatives for knowledge-based economic development. The authors argue that, as opposed to models consisting of three separate spheres or the governmental sphere encompassing the other two, the triple-helix overlay model (also named Triple Helix III) allows for the existence of an innovative environment that is encouraged, but not controlled, by the government [13]. The model builds on the concept of mode 2 (see §2.2.1), by forming a framework for institutional interconnections. The triple-helix model therefore enables the shift of scientific knowledge and innovation production from mode 1 to mode 2. Nowadays, the triple-helix model is a widely adopted framework by policy makers around the world, which has transformed the involved sectors and allowed for the emergence of hybrid organisations and social development, as was hypothesised by Etzkowitz and Leydesdorff [18].

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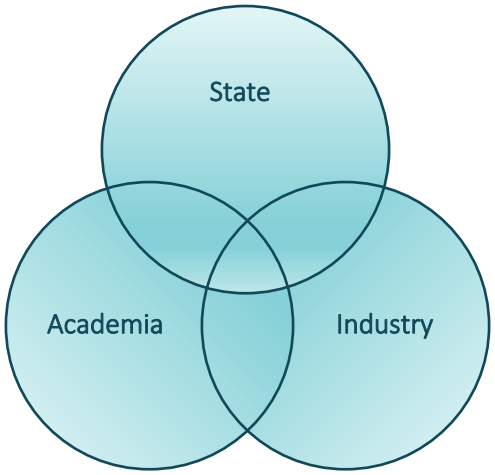

Figure 4. The Triple-helix overlay model (adapted from Etzkowitz & Leydesdorff 2000 [13, page 111]).

2.2.3 The Quadruple-helix framework

In an article from 2009 Carayannis and Campbell suggest adding a fourth helix to the framework; 'media-based and culture-based public' (Figure 5) [16]. The fourth helix was conceptualised because culture and media influence innovation systems and their likelihood to succeed. Especially in recent years the influence of the media and the opinion of the public on political communication has increased. The fourth helix therefore incorporates this so-called 'media-based democracy', where legitimation and justification of innovation ideas by the public are part of the innovation ecosystem. The fourth helix, also sometimes referred to as 'civil society', covers concepts like 'culture', 'value', 'lifestyle', 'art', and 'creative industries' [19]. The quadruple-helix framework enables the shift of knowledge and innovation production from mode 2 to mode 3 and has been applied to several EU-sponsored projects and policies [20; 21].

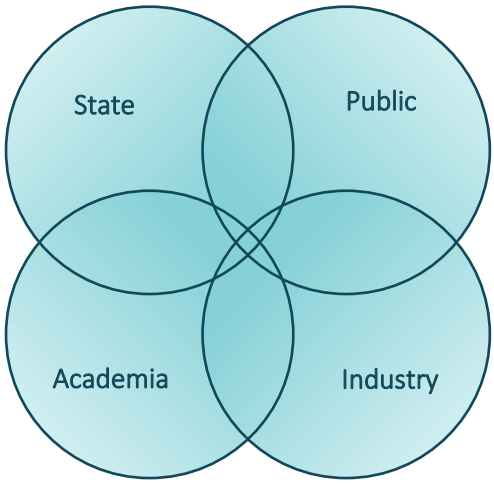

Figure 5. The Quadruple-Helix framework (adapted from Lindberg et al. *2012 [22, page 102]).*

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2.2.4 The Quintuple-helix framework

The quintuple-helix framework was introduced a year later by the same authors (Carayannis & Campbell, 2010 [23]). The innovation model is broadened further by adding a fifth helix: the natural environments of society (Figure 6). In this model, the environment is regarded as a driver for knowledge production and innovation and encompasses all other helices. If knowledge creation and education on sustainable development are stimulated and invested in, it will improve human capital on this topic, in turn creating opportunities in the economic sector, such as new jobs, products, and services, as well as new values in regard to sustainability. These new values will be taken over by the media-based and culture-based public, creating more incentives for additional knowledge creation and sustainable development, until it becomes part of the political agenda. Knowledge is then circulated back into the education system, the economic system, the environment, and the public [19]. The quintuple-helix is being incorporated into a growing amount of projects and policies, including the Green Deal (see §3.2.7.1) [21].

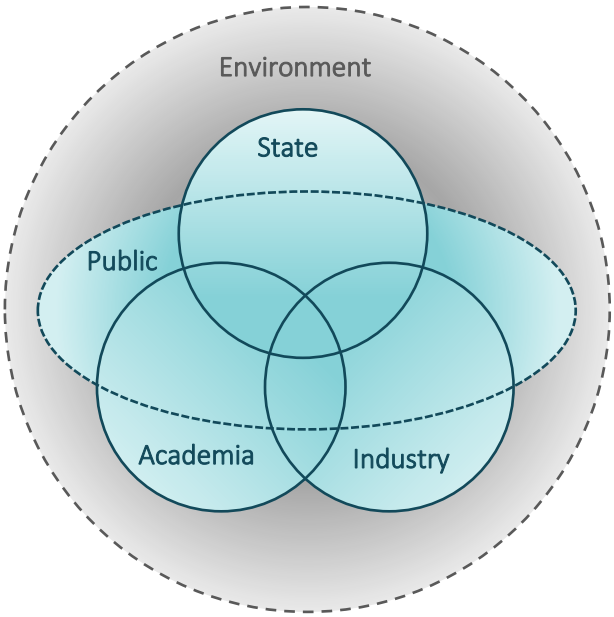

Figure 6. The Quintuple-helix framework (adapted from Carayannis and Campbell 2022 [24, page 72]).

2.2.5 The Penta-helix framework

In an article from 2020 [25], Igor Calzada proposes to extend the triple- and quadruple-helix frameworks from a SI perspective by including a helix for 'social entrepreneurs/activists' (figure 6). The penta-helix model was constructed because of the need for a multi-stakeholder approach in smart city policies and the resulting social/business models. The author argues that the triple- and quadruple-helix frameworks are too focussed on institutions while neglecting entrepreneurial cooperative networks of individuals and civic groups. This way, smart city policy is becoming more technocratic than democratic and citizen-focussed, especially with the increased use of algorithms. The penta-helix framework emphasises the role that people and organisations play in connecting the other four helices of the framework, therefore enabling more diversity in multi-stakeholder composition and resulting business/social models, the use of intermediaries between institutions, and the experimentation with democratic arrangements instead of a technocratic Public-Private-Partnership model. The application of the penta-helix

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multi-stakeholder SI framework was investigated through fieldwork action research, comprised of desk research, interviews, and workshops of three smart city case-studies and has shown promising results (see also §2.3.2) [25].

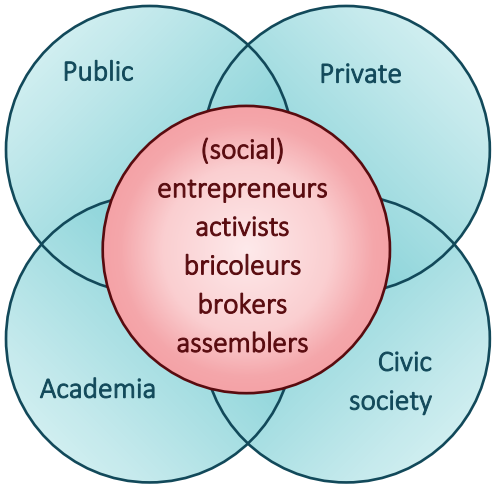

Figure 7. The Penta-helix framework (adapted from Calzada 2020 [25, page 1150]).

2.2.6 The Neo Triple-helix framework

The Neo triple-helix framework is a conceptual model introduced by Yuzhuo Cai in 2022 [27]. The model integrates the triple-, quadruple-, and quintuple-helix frameworks and is inspired by the work of evolutionary biologist Richard Lewontin; 'The Triple Helix: Gene, Organism, and Environment' [26]. In his book Lewontin argues that genes, organisms, and environments should not be seen as separate entities, but as part of an organic process, and that genes are not blueprints that determine the development of an organism, but that the interplay between the three components is much more complex than generally assumed. Cai makes a comparison between the processes described by Lewontin and the dynamics of innovation ecosystems. This analogy is purely metaphorical and serves to simplify the complexity of the issue. In his article Cai argues that the triple-helix institutions (state, academia, and industry) represent the genes in Lewontin's model, social structures (as described in the quadruple-helix framework) represent organisms, and the environment is the natural environment in which we all operate (as was added in the quintuple-helix framework) (Figure 8). This model emphasises both the interactions between agents and those between agency-structures, and is aimed to enable concepts like sustainable innovation, cross-sectoral interactions, transnational spanning, and indirect relations. It is different from the quintuple-helix framework in that it envisions the triple-helix institutions on a different theoretical plane of existence than social structures and the natural environment. The Neo triple-helix model therefore rethinks the theoretical grounds of the other helices and tries to clarify their interrelations, while highlighting the transnational nature of innovation ecosystems [27].

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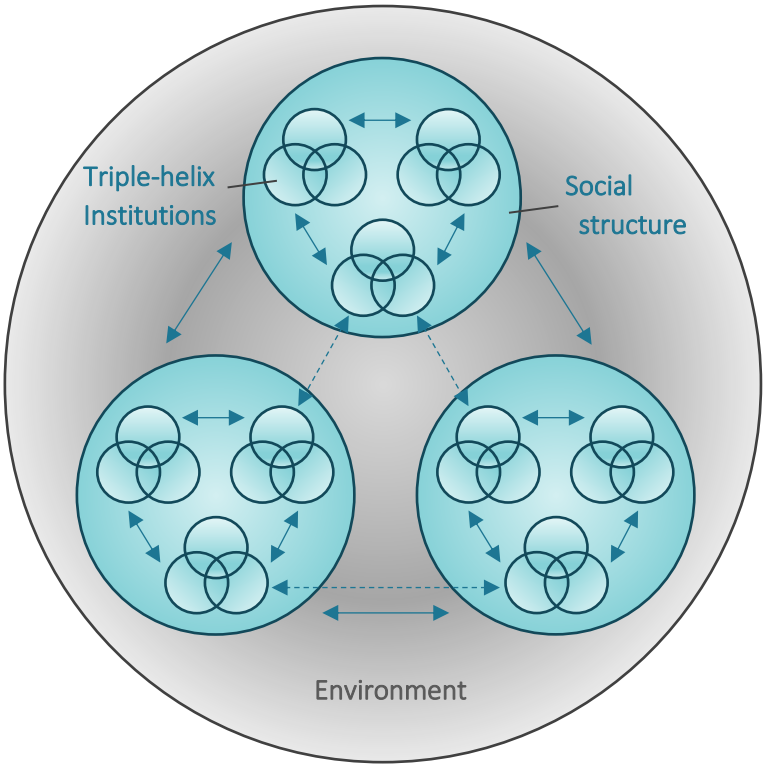

Figure 8. The Neo triple-helix framework (adapted from Cai 2022 [27, page 19]).

2.2.7 Incorporation into the SIRENE framework

During the proposal phase of the SIRENE project a combination of an ecosystem approach and the quintuple-helix model was envisioned as a foundation for the SIRENE social innovation framework. The quintuple-helix model was chosen to acknowledge the environment as a relevant actor in the ecosystem. The results of the desk research, however, bring to light models that were not previously considered. In order to remain true to the environmental and ecosystem aspects, and at the same time incorporate newer ideas on democratic policy-making and transnational spanning, a new model was chosen as a basis for the SIRENE framework: the Transnational Local-sphere Model (for a more elaborate description, see §6). This model will be used as a theoretical premise for the creation of the social innovation framework, and emphasises the important actors, institutions, stakeholders, networks, and principles that need to be taken into account.

2.3 Example of initiatives building on SI frameworks

This chapter features two SI projects listed in the CORDIS database (with an end date from 2018), which are based on the quintuple- or penta-helix frameworks. The other helix frameworks described in §2.2 were left out, because the quintuple- and penta-helix models incorporate all spheres of the triple- and quadruple-helix frameworks, but with additional elements that make these models more fitting for modern projects and initiatives. The neo triple-helix framework was left out because it was conceptualised in 2022 and there is no reference to be found to projects that use this model as a basis.

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The following search criteria were used: ('social innovation' AND ('quintuple' OR 'penta')). This search resulted in seven projects, a complete list can be found in Annex II CORDIS database search results chapter 2.3. The two projects described below are strong examples of how the quintuple- and penta-helix frameworks are integrated into SI initiatives.

2.3.1 RIPEET: Responsible research and Innovation Policy Experimentations for Energy Transition

Project RIPEET aims to support Responsible Research and Innovation (RRI) policy experimentation for the energy transition in three European regions (Extremadura, the Scottish Highlands and Islands, and Ostrobothnia). In these regions, so-called 'Transition Labs' will be established; co-creation environments for the testing of methods and tools. The RIPEET approach is based on the quintuple-helix framework, in which the Transitions Labs will serve to bring together the stakeholders of the five helices in a multi-level and bottom-up approach (Figure 9), in which stakeholders of the environment are defined as actors whose core attribute is environmental preservation. By applying RRI methods to territorial transition management, RIPEET tries to support the creation of new innovative ideas and more suitable solutions that will benefit the energy transition the most [28; 29].

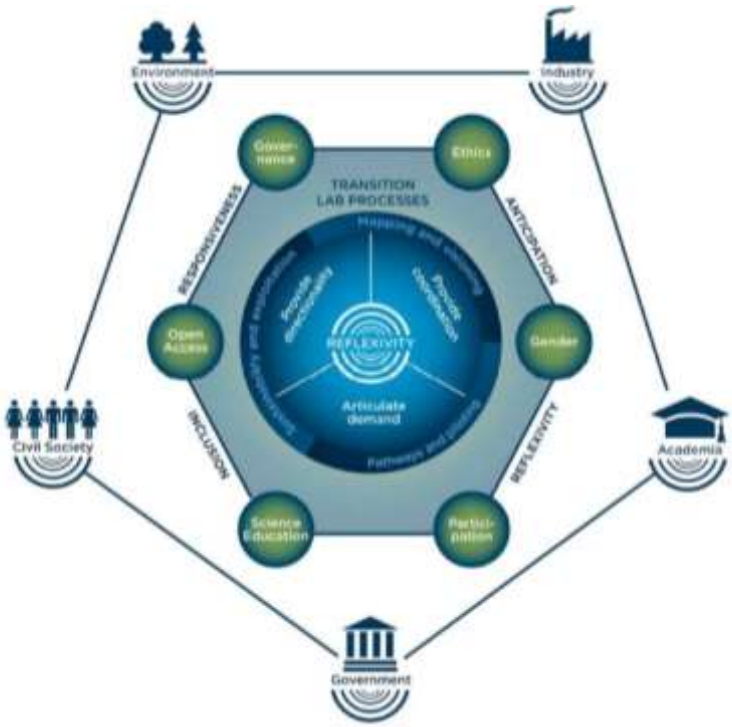

Figure 9. The RIPEET Transition Lab approach (taken from Enell-Nilsson et al. *2022 [29, page 9]).*

2.3.2 REPLICATE: REnaissance of PLaces with Innovative Citizenship And TEchnology

The REPLICATE project aimed to develop a City Business Model for the smart city transition process in the areas of energy efficiency, sustainable mobility, and ICT/infrastructure. This model was tested in three pilot lighthouse cities (San Sebastián, Florence, and Bristol), and focussed on replicability, sustainability, and scalability by using a multi-stakeholder approach [30]. The results of the pilot tests indicated that one stakeholder group, facilitators (like social

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innovators, entrepreneurs, and activists) is underrepresented in current approaches, but needed for a successful smart city transition. For this reason, the penta-helix multi-stakeholder policy framework was constructed, which incorporates this stakeholder group and its ability to connect the institutions of the other helices [31]. Although the environment does not have a prominent role in this framework, energy efficiency and the reduction of greenhouse gases are part of the REPLICATE City Business Model.

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3 Responsive, inclusive, eco-friendly environments

3.1 Introduction and definitions

Terms such as “smart”, “intelligent”, “interactive”, “adaptive” or “responsive” have been used loosely and interchangeably, creating confusion as to their specific meaning and their conceptual relationship to building performance and design. This subchapter will therefore explain the meaning of these terms and how continuous innovations create better and more adaptable environments for people to live in. A short definition of each concept can be found in Annex I Glossary.

In the Final Report of the Smart and Sustainable Cities and Communities Coordination Group (SSCC-CG) [32] the word “**smart**” is related to the integration between systems and between the “physical and the digital” and “common understandings”. An important aspect of this definition is a citizen-centred perspective and a ‘Design for All’ approach where accessibility is a key feature of making living environments age-friendly.
The WHO [33] defines an “**age-friendly city**” in a similar way, involving eight categories based on focus groups and previous research including older adults: outdoor spaces and buildings, transportation, housing, respect and social inclusion, civic participation and employment, communication and information, and social support and healthcare (Figure 10). Each category contains several features addressing aspects like affordability, accessibility, inclusiveness, and other related topics.

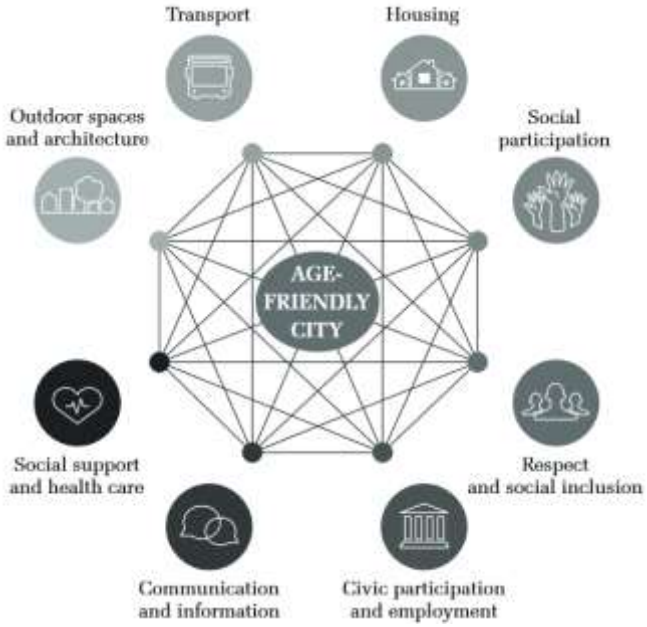

Figure 10. The eight categories of a smart city (taken from Brdulak 2017 [34, page 72], adapted from WHO 2007 [33]).

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The term "**intelligent**" is less focussed on integration and refers instead to those elements that measure the environmental conditions inside and outside the house, that decide how to provide a convenient and comfortable environment for occupants, and that respond promptly to occupant requests. To make a building intelligent a number of sensing devices is used, that together optimise interior conditions, and are adjustable by its occupants [35].

Figure 11. Artistic impression of a smart building (www.freepik.com [36]).

In contrast, a **smart building** is composed of an integrated building system that allows for adaptability, instead of reactivity. A smart building (Figure 11) should meet the drivers for building progression: energy and efficiency, longevity, and comfort and satisfaction. In essence, a smart building is an intelligent building with the additional aspect of adaptable control, enterprise, materials, and construction [37].

However, a home should not only be smart, it should also be **responsive**. The term "responsive" is often used interchangeably with "interactive" and "adaptive", but is most commonly described as "how natural and artificial systems can interact and adapt" [38; 39]. The term **adaptive** is similar and refers to something that is capable of alteration in response to its environment [40]. Responsive architecture takes an active role, initiating changes to a greater or lesser degree as a result and function of complex or simple computations. A responsive building includes functionalities and performance characteristics similar to those of an "intelligent" building including real-time sensing, climate-adaptive elements, smart eHealth devices, automation and the ability for user override. But it also includes interactive characteristics, such as computational algorithms that allow the building system to self-adjust and learn over time, as well as the ability for occupants to physically manipulate elements of the house to control environmental conditions, comfort, security and energy consumption [41].

The term "**interactive**" is used less frequently regarding the built environment than in reference to computer-enabled artworks, installations and other such environments encouraging active public participation. The past twenty years have witnessed an explosive rise in the number and range of interactive devices used to this end; in part due to the increasing miniaturisation of technology, rendering the sensing, computational and micro processing components necessary for their widespread adoption ubiquitous and inexpensive. Devices that come under the umbrella term 'Internet of Things (IoT)' are included here [42].

But why responsive (and interactive) and not only smart? A responsive environment reacts quickly and positively to user needs and behavioural changes in a manner that prioritises the comfort, safety and wellbeing of users over other considerations. The word "responsive" accommodates the wishes of residents and suggests a level of 'control' of the various modifications and adaptations of the environment. This allows, therefore, for the exercise of choice by residents regarding the acceptance of the ICT and of control over the parameters within which the ICT operates. According to Atkin [35], buildings should 'know what's happening inside and immediately outside'; 'decide the most efficient way of providing a convenient, comfortable and productive environment for the occupants'; and 'respond quickly to occupants' requests'. The house therefore becomes a humanised ambient system, which senses, adapts and reacts to human challenges. It also needs to be part of the community, enabling for example service provision without compromising personal data safety. It follows that although the

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'responsiveness' is intended to be automated, it should not be "out of control" and safeguards for residents will be incorporated. This means that to be truly smart, a building cannot consider ICT and accessibility issues narrowly; it must acknowledge and facilitate the active living of residents. That 'active living' will, for most, include involvement in the economic and social lives of their communities – this, in part, is facilitated by the same ICT that produces intuitive interfaces that are understandable and accessible, and that support independent living in its more physical sense. **A responsive, inclusive, eco-friendly living environment** (Figure 12), in other words, cannot be judged as such solely by reference to technology and physical design (that facilitates comfort, access and mobility) but the additional element being the extent to which the potential for greater engagement, inclusion and privacy is offered. Responsive, inclusive and eco-friendly living environments are environments that are designed or reconfigured to be more versatile, easy to enter, easy to navigate in and around, to better meet the changing needs of occupants over their lifetimes, to be capable of easy and cost-effective adaptation, and, of course, to ensure they are environmentally friendly, concerning the materials used, the energy or water consumption, and the use of local suppliers.

Figure 12. Artistic impression of a responsive inclusive eco-friendly living environment (www.freepik.com [43]).

A responsive, inclusive, and eco-friendly environment should:

1. Embed technologies that compensate for any deficits in users' capabilities;
2. Use technologies to improve the lack of accessibility not reachable with architectural/building apparatus.
3. Be designed or redesigned with adaptable, reusable frameworks, for a continuous adaptation of services to users;
4. Have a level of intelligence that enables services to be done better;
5. Devices, data, information and management systems should be available to the consumer, with an interoperable and simple user interface that allows the user to control privacy settings, services, according to the GDPR;
6. Provide efficiency in terms of safety, security, independent living and in energy and water saving, being resistant to climate change and extreme weather conditions;
7. Encourage and facilitate the participation of the occupant in the neighbourhood and social context [44; 45; 46].

Even though consensus is still lacking on the use of concepts such as smart, intelligent, responsive, and interactive, they all refer to an environment that consists of services, technology, infrastructure and so forth, and is designed to facilitate life at home and in the community. Topics such as age-friendly cities, housing, and (living) environments, independent or assisted living, and inclusive design refer to the idea that people with lower functional abilities

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are in many instances able to live at home, if supported by an such a smart, intelligent, responsive environment.

3.2 Overview of relevant social innovation projects and networks and their inclusion in innovation ecosystems

The following chapter includes examples of projects and networks related to responsive, inclusive, eco-friendly living environments and their relation to the SI ecosystem. These initiatives are highlighted, because they are the networks and flagships brought by the project partners of SIRENE. Subchapter 3.2.6 contains additional projects from the private sector, relevant networks that could be utilised in the SI framework, and projects that have created an extensive database of social innovation initiatives, which can used as a reference.

3.2.1 The SHAFE network

SHAFE - Smart Healthy Age-Friendly Environments – was a thematic network aimed to promote a concerted approach to healthy and active living, equity in access to service, and active participation in society, with the use of digital innovations and services. It was developed in 2018 by Cáritas Diocesana de Coimbra and AFEdemy and has grown into a European Stakeholders Network led by AFEdemy and SHINE with over 170 partner organisations, who use the concept of SHAFE as an objective and methodology in their initiatives. The aim is to better align ICT and built environments on a policy level to create a more user-centred approach. SHAFE is currently a Foundation and follows the United Nations Sustainability Developments Goals [55; 56].

Hands-on SHAFE is a project derived from this concept, which aims to develop a business that offers informal learning experiences and hands-on tools to implement smart, healthy, built environments [57].

3.2.2 COST Action 19136 NET4Age-Friendly

The COST Action 19136, NET4Age-Friendly – International Interdisciplinary Network on health and wellbeing in an age-friendly digital world – is an international network composed of nearly 500 members from 51 countries. The network aims to promote the creation and implementation of smart, healthy, and inclusive environments within the SHAFE framework by establishing interdisciplinary and Pan-European collaboration possibilities. The currently existing SI initiatives often run short because of difficulties in connecting researchers and stakeholders from different countries and policy backgrounds. COST Action therefore aims to improve chances for Early Career Investigators (ECIs), entrepreneurs, public authorities, and citizens by accomplishing several research coordination and capacity building objectives, by focussing on user-centred principles, and by accumulating and sharing knowledge on societal areas related to SHAFE [55; 58].

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3.2.3 CSA Homes4Life

Homes4Life (Certified smart and integrated living environments for ageing well) contributed to the development of a European framework for age-friendly living environments by developing a certification scheme that integrated both ICT and construction. The main objective of H4L was to support investment in the domain of age-friendly environments. During the scope of the project 11 buildings have been successfully tested by using this certification scheme. Homes4Life also delivered a set of guidelines and tools for the creation of businesses and policies, as well as a taxonomy and a KPI definition methodology presenting a structured and detailed breakdown of what it means for a home to be age-friendly (see also §3.3.1) [59]. The H4L framework is user-centred and follows a holistic and life-course approach and tries to break with the shortcomings of previous certification schemes, which were found to have a very one-sided definition of 'age-friendly', a limited and unclear perspective, a cost-based view, and too much focus on new builds [60].

3.2.4 The Thematic Innovation Ecosystem on Housing and Health

The Thematic Innovation Ecosystem (TIEs) on Housing & Health is an initiative from the European Connected Health Alliance Group (ECHAlliance Group). ECHAlliance is a multi-stakeholder network that facilitates connections around ecosystems, sustainable change, and health and social care. The ECHAlliance ecosystems, including 12 TIEs, are regional multi-stakeholder partnerships which have been implemented in over 70 locations. They aim to 'improve the quality of health and wellbeing of citizens, the effectiveness of the healthcare system and the scope for wealth creation and business opportunities' [61]. The Thematic Innovation Ecosystems target eight areas: Digital health and wellbeing, skills for health, integrated health, housing and health, mental health, and health procurement. The TIE on Housing & Health enables collaboration between ECHAlliance members worldwide on R&I initiatives relating to smart, healthy, inclusive housing [62].

Figure 13. A visualisation of the ECHAlliance ecosystem model (taken from www.echalliance.com/ecosystems [61]).

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3.2.5 The European Reference Framework on Smart Age-Friendly Housing

The European Reference Framework on Smart Age-Friendly Housing (ERF-AFH) was developed by a European-wide stakeholder consultation process named 'the Neighbourhoods of the Future Roadshow'. The ERF-AFH initiative was created because the current built environment in Europe does not support age-friendly independent living, and the replacement rates are too low to keep up with the rising demand. The European Reference Framework was therefore aimed to mainstream available solutions by fostering innovation on European, national, and regional level. To obtain a collection of expertise, innovation ecosystems, and resources, a series of co-creation workshops was conducted in six European countries starting in 2016. This allowed for the inclusion of initiatives that would otherwise not have been included, i.e. because of language barriers [63]. This methodology seems to be in line with the penta-helix framework, which calls for a democratic multi-stakeholder approach (see §2.2.5).

3.2.6 DESIRE

DESIRE (DESIgn for all methods to cREate age-friendly housing) is an EU funded project aiming to improve house design to accommodate the needs of older people. The project's objective is to provide building and home furnishing professionals with the tools and skills to apply the Design4All (D4All) methodology to create or adapt houses to be more age-friendly. D4All is an age-friendly design consultancy co-founded by industrial designer Ron Nabarro. Their well-established approach is user-centred and focusses on making technology available and accessible for older adults. Project DESIRE has created an innovative training course on D4All, raised awareness on age-friendly housing, and fostered interactions and knowledge exchange between the different disciplines involved in the design process [68].

3.2.7 Other pilots and initiatives that relate to RRI and Social Innovation practices

3.2.7.1 The Green Deal

The Green Deal is an initiative from the European Commission, comprised of a set of proposals to reduce Europe's net greenhouse gas emissions by at least 55% in 2030 and by 100% in 2050. The initiative was presented in 2019 due to the growing threat of climate change and environmental degradation. The Green Deal includes proposals for making buildings energy efficient with cutting-edge clean technological innovations, and for adapting homes to be smarter, more responsive and eco-friendlier [64]. One of these proposals is called 'the New European Bauhaus', which aims to connect the Green Deal to our daily lives and living spaces by creating sustainable, aesthetically pleasing, and inclusive environments [65]. The Green Deal uses the quintuple-helix framework for social innovation (see §2.2.4).

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3.2.7.2 The OECD LEED forum on Social Innovations

The OECD Local Employment and Economic Programme (LEED) was founded in 1982 as a result of the recession. LEED aims to create more and better jobs through effective policy implementation and local initiatives, drawing on experience in policy making from over 50 countries worldwide [66]. From this programme the OECD LEED forum on Social Innovations (FSI) was created in the year 2000, in collaboration with eleven organisations from six different countries (Canada, France, Italy, Mexico, Spain, and the USA). This multi-stakeholder forum consists of private, public, and non-profit organisations, who share their knowledge and expertise and together aim to identify the most successful social innovations, and to facilitate their implementation locally [67].

3.2.7.3 SmartBuilt4EU

The SmartBuilt4EU project works towards increasing the market uptake of smart building technology by fostering collaboration between stakeholders, supporting new smart building innovations, identifying barriers, opportunities, and best practices, and drawing recommendations to policy makers. For this purpose a Smart Building Innovation Platform was set up, featuring four different task forces that investigate key issues and trends in the areas of 'interactions with users', 'efficient building operation', 'interactions with the external environment', and 'cross-cutting issues' [69; 70]. In addition, a Smart Readiness Indicator (SRI) was developed; a tool that helps in the assessment of smart building technologies, which will support the integration of cutting-edge technologies in the design and development of new buildings. The SRI provides a scoring methodology in three distinct categories: energy efficiency, energy flexibility, and operation needs of the occupants [71].

3.2.7.4 Lugaritz - Homes for a Lifetime

'Lugaritz – Homes for a lifetime' is an innovative age-friendly housing project in the city of San Sebastian in Spain. The project is aimed towards older individuals who are in need of support, but would like to keep living their lives at home with their families. For this peer group residences will be developed which allow for the coexistence of couples or family cohabitation units. The homes will be designed to be both accessible and allow for the privacy of its residents. The residences will be integrated into the community, where services, benefits, and resources will be provided by the community through the creation of a social network. Lugaritz aims to promote neighbourhood connectivity and friendliness in surrounding public spaces, creating an attractive, inclusive neighbourhood for all. The Lugaritz project is a collaboration between the municipality of San Sebastian and the Matia Foundation (a non-profit organisation) [72; 73].

3.2.7.5 The Hogeweyk

The Hogeweyk is a so-called 'dementia village' in Weesp, the Netherlands. It is a new, more humane, form of nursing home care for people with severe dementia, enabling them to keep living a normal life. The Hogeweyk is a closed of neighbourhood complete with houses, parks, supermarket, restaurant, theatre, and pub. The 187 residents live divided over 27 residences, each with a permanent nursing care team. The residents of Hogeweyk are free to visit the

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neighbourhood and participate in activities and clubs, all of which are adapted to their unique needs. This new way of nursing home care allows for people to have more freedom, make their own choices, and participate in chores and daily life activities, which decreases boredom, loneliness, and hopelessness for people suffering from dementia. The Hogeweyk is a collaboration between the Vivium Care Group (a care specialist) and BuroKade (a design agency) [74; 75].

3.2.7.6 SI-DRIVE: Mapping of SI initiatives

Social innovation initiatives were compiled within the project SI-DRIVE. In the scope of this project an 'Atlas of Social Innovation' was constructed, offering an overview of the often complicated concept of SI [76]. The atlas aims to integrate SI theories and methodologies to form a new paradigm of innovation. Additionally, an interactive map of social innovation initiatives was made, displaying more than a 1000 SI initiatives worldwide in different central policy areas (Figure 14). The SI-DRIVE project has emphasized the importance of cross-sectoral collaborations in SI ecosystems and the lack of a proper user-centred policy framework in Europe and on a global scale [77].

Figure 14. The map of social innovation initiatives (screenshot of www.socialinnovationatlas.net/map [78]).

3.2.7.7 DSI4EU: Digital Social Innovation in Europe

The Digital Social Innovation in Europe (DSI4EU) project, which finished in 2017, aimed to support the growth of digital social innovation and expand the DSI network by bringing together social entrepreneurs, hackers, communities, and academics. For this purpose, DSI4EU has developed a crowdsourced database including over 1200 organisations and 800 digital SI projects, such as online platforms, open-access soft- or hardware, citizen sensing kits, and blockchain (Figure 15). The database can be used for organisations to showcase their work and tag their organisations as part of networks, to search out existing organisations and projects for research or collaboration purposes, to identify funding and support opportunities, to find or promote events, and to learn more about DSI opportunities in Europe through case studies, blogs, and trends [79; 80].

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Figure 15. The DSI4EU database (screenshot of www.digitalsocial.eu [81]).

3.3 Collection and mapping of SI initiatives relating to responsive environments

This chapter features a brief overview of projects listed in the CORDIS database (completed between 2018 and 2022), which focus on the topic of responsive environments for independent living for all generations. Because terms related to this concept are often used interchangeably (see §3.1), the following search criteria were used: ('smart environment*' OR 'inclusive environment*' OR 'responsive environment*' OR 'interactive environment*' OR 'age-friendly environment*' OR 'smart living' OR 'inclusive living' OR 'responsive living' OR 'interactive living' OR 'age-friendly living' OR 'smart cit*' OR 'inclusive cit*' OR 'responsive cit*' OR 'interactive cit*' OR 'age-friendly cit*') AND ('independent living' OR 'assisted living'). This search resulted in fourteen projects, of which one was excluded because it was not relevant to the search criteria. A complete list of the remaining thirteen projects can be found in Annex III CORDIS database search results chapter 3.2. Of these projects, four were further selected for the purpose of this desk research, because they contain relevant components that can be integrated into the SI framework that will be developed for SIRENE. A description of these projects will follow below. The research that has been done during these projects can give valuable insights into good practices, methodologies, analyses, or frameworks that were developed specifically for responsive environments. These methodologies and good practices will be used in the creation of the SIRENE SI framework and its Manual, by building on the gathered knowledge and research and by making use of consisting networks and methods.

3.3.1 Homes4Life: Age-friendly living environments initiatives

Homes4Life (H4L) aimed to support investment in the domain of age-friendly environments, by developing a certification scheme that integrated both ICT and construction (see also §3.2.3). During the H4L project, the existing research and innovation initiatives for age-friendly living environments at European, national, and regional levels have been investigated. In total 21

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projects were identified based on three main categories: large-scale IoT pilots, smart living environments, and independent living and ageing well. The projects were then analysed and divided into three areas relating to the central themes of the H4L project: physical environment, technology, and health and social aspects of ageing. From the results (Figure 16) could be concluded that most initiatives cover the topic of 'technology for health and social aspects' [47].

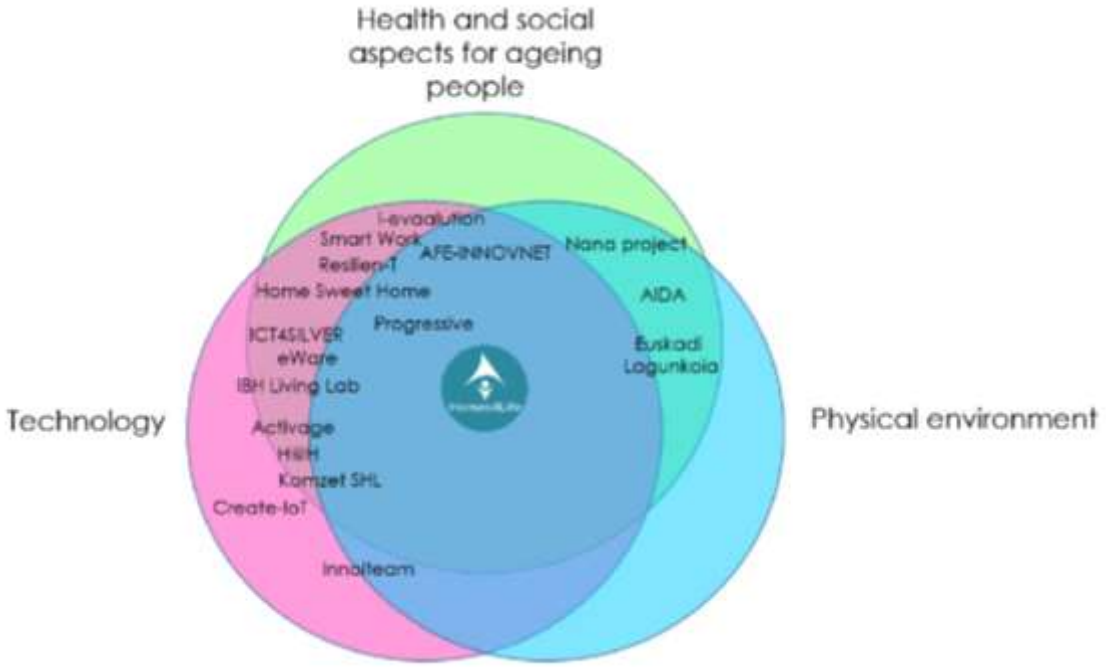

Figure 16. Results of the Homes4Life existing R&I initiatives report (taken from Casaccia 2019 [47, page 31]).

The results were also compared to the taxonomy and KPI-framework of Homes4Life, in which five clusters were identified:

- Physical cluster (personal safety, comfort, accessibility and orientation, health and social care, smart readiness);
- Outdoor accessibility cluster (home and building, immediate environment, neighbourhood, or village);
- Personal cluster (identity and emotional connectivity, privacy and dignity);
- Social cluster (social activity, employment);
- Economic cluster (affordability, choice).

It was concluded that research-oriented projects mostly encompass part of the physical cluster, while research in other areas is scarce. In addition, 34 certification schemes, 10 laws and regulations, and 8 local initiatives and other good practices were identified, of which 15 certification schemes were selected for analysis. Most certification schemes turn out to deal with physical aspects or outdoor accessibility [47]. In conclusion, it can be stated that both research initiatives and certification schemes are lacking for the personal, social and economic sides of smart and integrated living environments.

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3.3.2 IDIH: International Digital Health Collaboration for Preventive, Integrated, Independent, and Inclusive Living

The IDIH project aimed to improve international cooperation in the area of digital technologies for active and healthy ageing (AHA) between the EU and five strategic countries outside of Europe (Canada, China, Japan, South Korea, and the USA). The premise of the project was that current ICT offers are often inaccessible to citizens because they are not affordable, not interoperable, or not user-centred. The IDIH vision is therefore to improve these issues by providing international collaboration possibilities. For this purpose, a Digital Health Transformation Forum was set up, consisting of four expert groups: 'preventive care', 'integrated care', 'independent and connected living', and 'inclusive living'. The forum serves as a way to exchange knowledge, provoke discussion, and enable synergies [48]. One of the outcomes of the forum is the 'roadmap towards international collaboration', which describes the areas of AHA that need to be enhanced and how to accomplish this. The roadmap contains a framework for policy makers for the formation, implementation, and evaluation of AHA programmes. This framework is based on the quadruple helix model, combining an expert-driven approach with a user-centred perspective through the organisation of knowledge mobilisation workshops. The same methodology was used for the creation of the roadmap (Figure 17). The document further contains available funding schemes, current networks, organisations, and users' associations, as well as a list of recommended actions and evaluation methods [49].

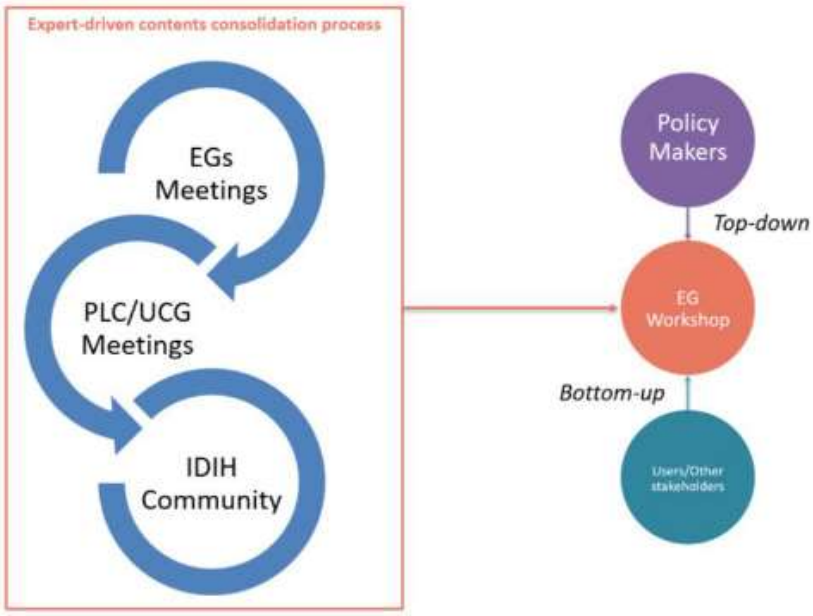

Figure 17. Methodology of the IDIH roadmap (taken from Zissis & De Bonis 2022 [49, page 10]).

3.3.3 ACTIVAGE: ACTivating InnoVative IoT smart living environments for AGEing well

The ACTIVAGE project aimed to develop a set of tools, techniques, methods, and frameworks to enable interoperability between IoT-enabled AHA technology in smart living environments. For this purpose, the IoT ecosystem suite AIOTES was built, which focuses on the safety and independence of older adults in need of care. Their software includes health monitoring,

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cognitive stimulation, and social engagement and is user-demand driven. The unified framework overcomes existing fragmentation issues and integrates different IoT technologies [50].
The ACTIVAGE solution aimed to be a value-driven innovation, including several stakeholders (patients, families, service providers, taxpayers, etc.) with a two-layered *glocal* perspective and a bottom-up approach. This *glocal* methodology (Figure 18) is based on both **quantitative data** through questionnaires, standard scales, and data logs, and **qualitative data** through focus groups, interviews and local information sources [51]. This approach therefore incorporates a multi-level and multi-stakeholder methodology and is user-centred, which corresponds to the mode 3 innovation model (see §2.2.1). To demonstrate the effectiveness and sustainability of this approach a white book was written on how AHA IoT-based services can benefit its users [52]. The project also developed a set of tools for a user-centred design methodology. User-centred design is obtained through a combination of a documentary analysis, and focus and working groups, consisting of target users, caregivers, professionals, and key informants [53].

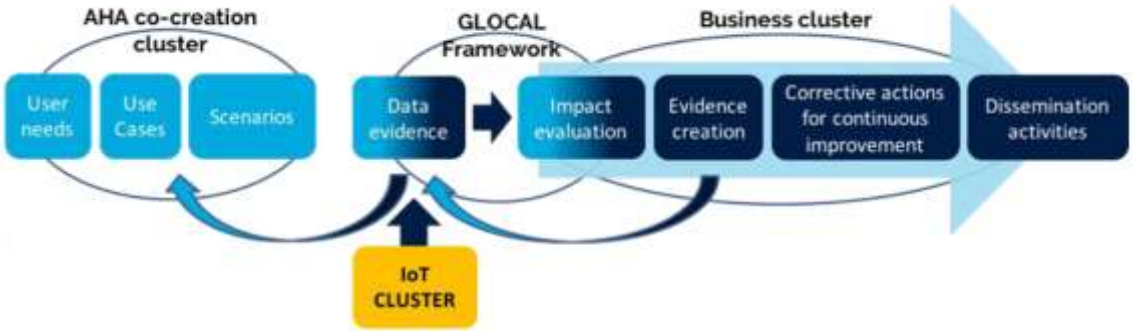

Figure 18. The ACTIVAGE Glocal methodology framework (taken from Tamburini et al. *2018 [51, page 10]).*

3.3.4 INTER-IoT: Interoperability of Heterogeneous IoT Platforms

INTER-IoT is another EU initiative aimed to improve the interoperability of IoT components by developing software tools that enable interoperability between already existing IoT devices and platforms.
For the project an ethical review of data management was conducted, based on the eight principles of the GDPR (see §5.1.1). The following ethical assessment was made during the INTER-IoT project:

Table 1. Ethical assessment made for the INTER-IoT project (adapted from Llorente et al. *2017 [54, page 139-140]).*

Requirement	Principle	Actions
System security and privacy	1, 2, 6, 7	Controlling access to the INTER-FW and other systems connected to INTER-FW is necessary to allow users to determine who can access what data and how it can be utilized.
Auditability	1, 2, 5, 7, 8	A history including the source of data, modifications to data, and viewing of data is necessary to ensure that proper usage is controlled.
Constraints on processing of personal and health data	1, 2, 6, 7	Providing the tools so a user can ensure that they are collecting the correct data and the data is being used only for the purposes necessary to allow appropriate

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		data management for processing of health and personal data.
Confidentiality	1, 7	Providing the tools to ensure data can be isolate within the system so no other users will know about it or a description of it is necessary.
Users manage how their public data is seen	1, 7	Allowing users to manage how their data is seen, provides a way to ensure data is processed appropriately and ethically.
Manage user permission	1, 2, 7	Access to data needs to be controlled on a per user basis. Tools for controlling access to specific parts of INTER-IoT are provided by INTER-FW.

Although the target audience of the INTER-IoT project is much broader than for SIRENE, a similar ethical assessment needs to be applied on the IoT platforms used in smart living environments before such components can be integrated (see chapter 0).

3.4 Overview of social innovation methods and practices, and a collection of standards and guidelines

This chapter will give an overview of methodologies, frameworks and good practices from initiatives and networks mentioned in the chapters above. By building upon already established guidelines and research from other projects, the SIRENE solution can be more sustainable and better catered to the needs of all the stakeholders involved.

3.4.1 Values and perspectives

Population projections for the EU indicate that by 2050 the percentage of individuals aged 65+ will have increased by 9,1% compared to 2019, meaning that almost 30% of the entire EU population will be above the current average retirement age. This so-called demographic ageing is expected to have a profound effect on social and economic issues, such as health and social care systems, labour markets, public finances, and pension entitlements [82]. It is therefore imperative that individuals continue to be active members of society for as long as possible. The creation of age-friendly responsive environments will help in maintaining the independence and continued community involvement of older citizens and other less abled individuals and therefore ensure future economic growth and the wellbeing of all people [83; 84].

The effect of age-friendly solutions, as also described in the ACTIVAGE project [52], can be divided into **primary outcomes** (such as health and quality of life) and **secondary outcomes** (sustainability, and innovation and growth). There have been several studies around the world that investigated the primary outcomes of age-friendly environments for residents, all of which showed a significant positive effect on the wellbeing of (older) citizens, such as an increase in quality of life, satisfaction levels, and physical and mental health, and a decrease in depressive moods and loneliness [85; 86; 87; 88; 89; 90]. The factors by which age-friendliness is measured vary slightly per study, but commonly include factors such as safety, access to services, walkability, connectivity, aesthetics, community engagement, and social support.

These studies mainly focus on the benefits for primary end-users of age-friendly urban environments. However, there are other perspectives and scopes involved. For the project

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Homes4Life (see §3.3.1 & §3.2.3) a 'taxonomy' (descriptive framework) of age-friendly living environments was made, outlining the different functions and perspectives such an environment encompasses (Figure 19). This taxonomy is value-based and gives a comprehensive overview of the various components and stakeholders. The Homes4Life project has shown that responsive environment solutions should incorporate the perspectives of **users**, **relatives and informal carers**, and **organisations**. At the same time, the different functions of an age-friendly home (physical, outdoor, personal, social, and economic) should be considered during the development and implementation phase. So far, the personal, social, and economic sides have been underrepresented in past initiatives (see also §4). More research is needed on these subjects and a wider variety of stakeholders need to be included in the process to ensure that all functions of responsive environments and buildings are covered.

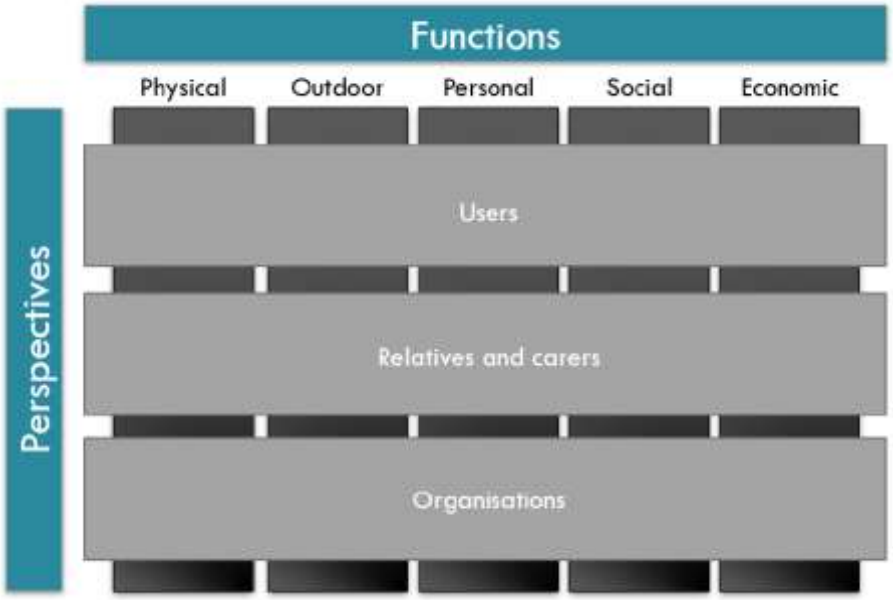

Figure 19. The Homes4Life taxonomy structure (taken from Hinkema and van Wissekerke 2019 [60, page 21]).

3.4.2 Standards for the creation of responsive environments

Secondary outcomes of age-friendly solutions can be divided into 'sustainability' and 'innovation and growth'. Key features for sustainability are user acceptance, interoperability, cost-effectiveness, and population density [52]. For user acceptance, **user-centrism** is an essential element, which reflects the approach many recent initiatives are taking. Co-creation workshops (like focus groups, working groups or knowledge mobilisation workshops) can help in establishing both an expert-driven and user-centred perspective. These workshops should implement a top-down and bottom-up approach, as was done in the IDIH and ACTIVAGE projects (see §3.3), incorporating experts, key informants, policy makers, primary end-users, and other stakeholders. This methodology helps in creating solutions catered to the needs of its users and is based on the quadruple-helix framework, although the same approach is incorporated in the quintuple-, penta-, and neo triple-helix frameworks as well (§2.2).

To be accepted solutions also need to be **accessible**, i.e. affordable, understandable (user-friendly), available (open-access), and inclusive. International collaboration is a key feature that will help in creating more accessible solutions, as well as a *glocal* approach. By combining knowledge and expertise through networks and forums, more knowledge and resources will

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become available which will lead to better targeted solutions and reduced costs. Including more actors and stakeholders in the process, like individuals and civic groups, will affirm democratic policy making and benefit the inclusiveness of products and services, as described in the penta-helix framework (§2.2.5).

For initiatives relating to technology, **interoperability** is a key feature, as described in the IDIH, INTER-IoT, and ACTIVAGE projects (§3.3). Interoperability will help in keeping solutions affordable and gives users more freedom of choice. In order to make IoT platforms interoperable an open cross-layer framework is needed incorporating all fundamental layers: device, networking, middleware, applications, and semantics [91]. Integrating interoperability on all layers will shorten development time, allow for the design and implementation of fully connected ecosystems, and enable global exploitation [92].

The third key feature of sustainability is **cost-effectiveness**. In healthcare, this is often measured by doing a costs utility analysis (CUA) [93], as was also done in the ACTIVAGE project [52]. In a CUA there are three options when a new technology or service is brought to the market: the new solution is more expensive and less effective than current offers, the new solution is less expensive and more effective than current offers, or the new solution is more expensive and more effective than current offers. In the first case, the new solution is not sustainable, in the second case it is sustainable, and in the third case the sustainability of the solution depends on the buyer's willingness to pay for the increased efficacy. This means that the cost-effectiveness of a responsive environment solution is dependent on by whom this is financed and who decides which technologies and services will be incorporated. The interests between the user and the financer may differ profoundly, therefore regulations are needed to prevent the financing party from choosing the cheapest option, regardless of its effectiveness.

The last key feature for sustainable age-friendly environments and active ageing solutions is **population density**. During the ACTIVAGE project, it was established that there exists a target market for AHA-IoT technologies: an ecosystem with a density population between 4000 and 6000 hb/km². The reasoning behind this is that population density impacts the quantity of care professionals, the availability of nearby services, transport duration, and the ability of informal caregivers to visit regularly. If population density is high, the abundance of resources makes IoT services less useful. On the other hand, if population density is low there are not enough resources to connect [52]. The same principle applies to age-friendly responsive environments, since part of the usefulness of a smart responsive building is the direct neighbourhood of the residents and the availability, connectivity, and closeness of services and contacts. When designing a smart city all these factors need to be incorporated and when designing a smart home the location may change the needs for certain services and appliances.

Innovation and market growth (the second secondary outcome) can be obtained by ensuring the **replicability and scalability** of a solution and through **synergies among stakeholders** [52]. According to the results of the REPLICATE project, a smart and sustainable city should spread innovations to multiple sectors and territories. For this, strong replicability is vital; innovations should be adaptable to different conditions that incorporate both technological and cultural factors, as well as financing. To create replicability, scalability, and synergies a wide range of enablers, technologies, stakeholders, and business models are needed, spanning a multitude of sectors and disciplines (Figure 20). During the REPLICATE pilot tests the role of the facilitator turned out to be especially useful for a successful smart city transition and the scaling-up and repeatability of solutions. This includes supporting agencies and third parties with technical

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expertise, who enable the overcoming of procedural obstacles and silos. This approach uses the penta-helix framework, incorporating these facilitator actors in order to connect the other stakeholders evolved in the process [31].

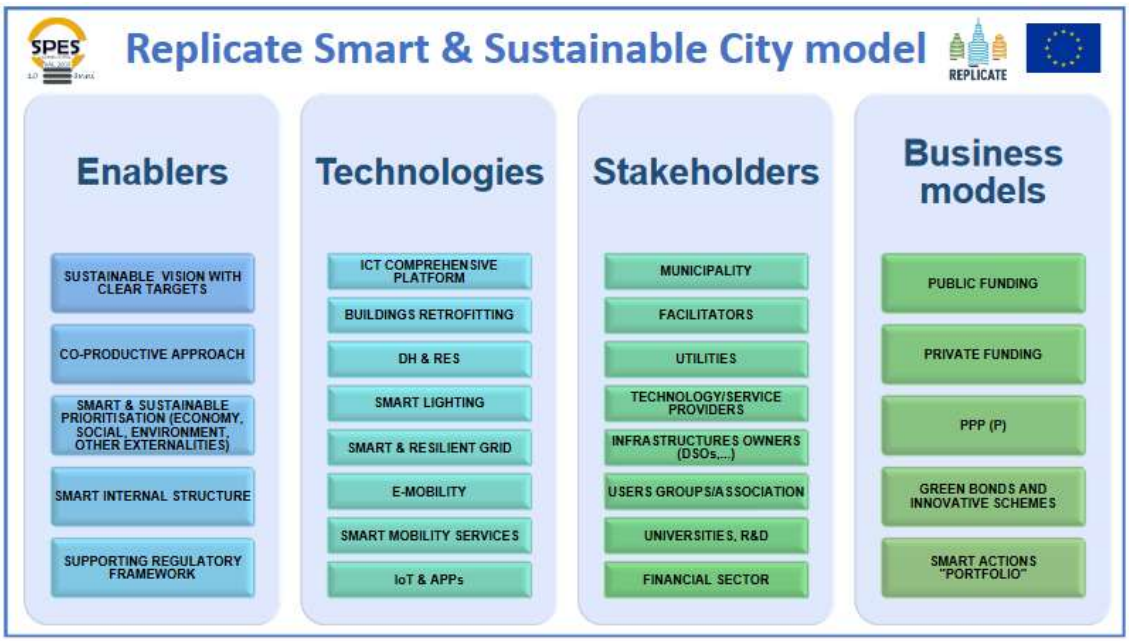

Figure 20. The REPLICATE smart and sustainable city model (taken from SPES 2020 [31, page 21]).

3.4.3 Tools that policy makers need to implement SI ecosystems

Even though social innovation ecosystems have not been implemented on a large scale (see §2.1), various countries and regions are taking steps towards it by using a bottom-up approach and developing innovative ICT solutions. However, due to this scattered growth of SI ecosystems, policies are often territory-specific and standards are lacking. Nevertheless, there are several actions local policy makers can take to enable SI innovations. The OECD LEED paper 'Building Local Ecosystems for Social Innovation, A Methodological Framework' provides an overview of such policy implementation mechanisms on a local level (Figure 21) [94].

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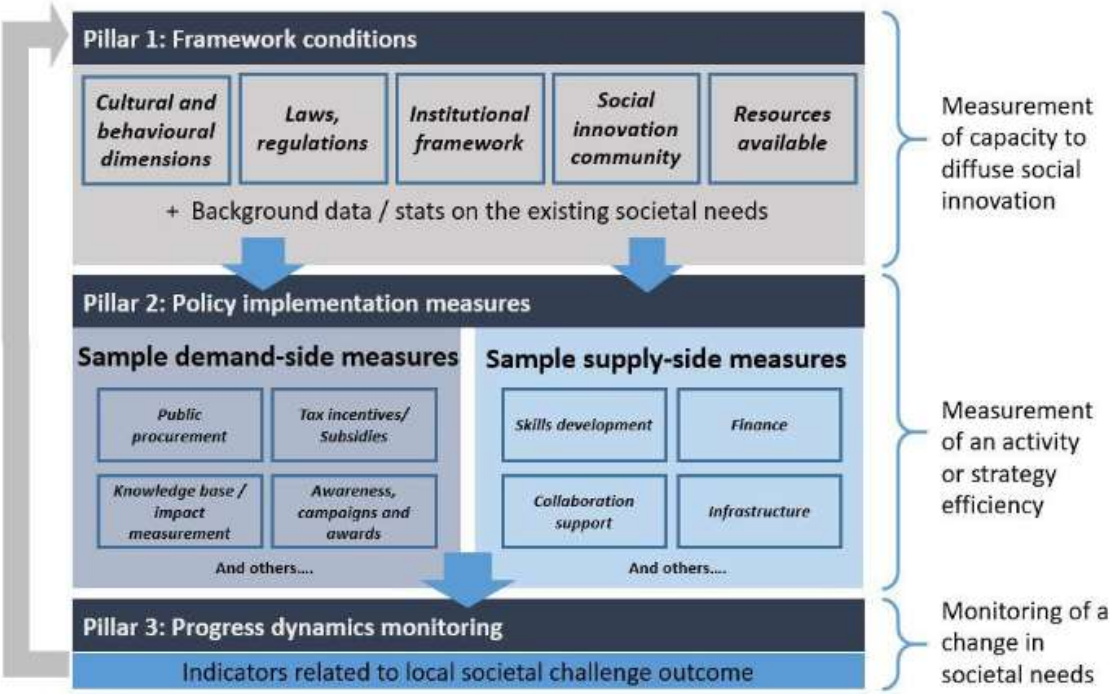

Figure 21. Analytical framework for the implementation of local SI ecosystems (taken from OECD 2021 [94, page 27]).

The framework consists of three pillars; the first step is an analysis of the existing situation and cooperation abilities. The second pillar describes which measures can be taken to support SI, and the last step is an analysis and adjustment of these measures. A distinction is made between demand-side measures, for creating an appropriate market, and supply-side measures, for increasing the quantity and quality. Demand-side measures include:

- Awareness campaigns and prizes
- Public procurement
- Supporting the knowledge base through impact measurement tools
- Tax incentives or subsidies

Supply-side measures include:

- Financial support
- Hard and soft infrastructure (i.e., physical infrastructure and support services)
- Skills development
- Collaboration

For the existence of a large-scale social innovation ecosystem change is needed in the current profit-oriented way of the entrepreneurial system. This system does not adequately support non-profit and private actors and lacks focus on value, causing SI solutions such as smart buildings to be less useful and accessible than needed to fully reach the societal impact it is aiming to achieve. This will require a change in governance models, supportive infrastructures, and legal and cultural norms (see §2.1); a gargantuan task that will take many years to accomplish. Therefore, it is more feasible to foster interrelations between local ecosystems, and to focus on building a transnational collaboration network to better support the creation and implementation of responsive environment solutions and improve the replicability and scalability of current offers.

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4 Gap analysis and mapping of strengths of social innovation frameworks in the area of responsive, inclusive and eco-friendly environments

4.1 Identified gaps and needs for primary end-users

As mentioned in Section 2.1, social innovation refers to the design and implementation of new solutions that imply conceptual, process, product, or organisational change, which ultimately aim to improve the welfare and wellbeing of individuals and communities. This change can come in many forms, from policies and regulations, to methods, ideology, and law. Yet there seems to be a disproportionate emphasis on technological solutions in social innovation initiatives. This reflects people's (mis)understanding of the concept, where any kind of innovation is automatically envisioned as technological advancement. And although it is certainly important, technology alone cannot fully change the way society functions.

This inattention to the social attributes of innovation is also visible in the approach many projects for age-friendly housing are taking. Most initiatives are technological solutions covering physical aspects, such as safety, comfort, accessibility to systems in the house, options to contact health services, and smart appliances. This was already established in the Homes4Life research on R&I initiatives [47] and was also reflected in the CORDIS database search, where most projects revolved around IoT platforms and smart devices (§3.3). Research initiatives and certification schemes are lacking for the personal, social and economic sides of smart and integrated living environments. This includes issues like the ability to have social contacts, proximity to facilities, affordability, autonomy and control, emotional connection to the location, removing stigmatisation, and decision-making authority. However, as was established in §3.1, a smart responsive eco-friendly living environment encompasses the active living of residents, including involvement in the economic and social lives of their communities. Therefore, a broader approach is needed, including aspects such as privacy, social activity, affordability, and personal choice.

4.2 Identified gaps and needs for providers and other stakeholders

Most research and projects in the area of responsive environments focus on the needs of the end-users. However, there are many other stakeholders involved from a variety of interests and sectors. This includes relatives and informal carers, and organisations, like health or service providers, local or regional government authorities, the (social) housing sector, construction and installation businesses, real-estate agents, energy suppliers and ICT companies. During the REPLICATE project, it was established that there exists a gap between the businesses that are currently involved and the implementation of smart city concepts. A possible solution could lie in packing projects together in a "smart city portfolio", which optimises primary outcomes, while simultaneously supporting market growth. These portfolios should contain a wide range of projects and stakeholders in order to represent the dynamic network that characterises smart cities, and to connect its elements on all levels [31].

In the scope of the NET4Age-Friendly objectives, a mapping of SI ecosystems connected to SHAFE was conducted to increase awareness of innovation actors and to leverage the creation of alliances and synergies between quadruple-helix stakeholders within and between

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ecosystems. For this purpose, a survey was conducted for the identification of SI ecosystems. From the survey was concluded that ecosystems are mainly structured by universities and research centres, in collaboration with public-institutional components. The voice of the private sector is underrepresented in this collaboration. In addition, a substantial percentage of solutions are not exploited and there seems to be little understanding of the processes involved (see also §2.1). There is therefore a need to broaden the base of informal stakeholders to accomplish social transformation and implement achieved results [8; 55]. This conclusion is similar to the one from the REPLICATE project in that entrepreneurial cooperative networks of individuals and civic groups are underrepresented entities, especially during the development phase, and working with intermediaries may lead to a more democratic process, like is proposed in the penta-helix framework (see §2.2.5).

4.3 Identified gaps and needs in research and education

In the SmartBuilt4EU project, the impact of smart ready technologies was investigated in several categories. It was concluded that the areas of energy efficiency, energy flexibility, and storage are widely investigated, but concepts such as health, well-being, accessibility, and convenience are underrepresented in research initiatives and the impact of these elements cannot be adequately assessed at this moment [71]. A similar conclusion was drawn in a literature review on smart age-friendly environments [95]. The article poses that more research is needed on the long-term value creation of digital technologies relating to health and care services in smart homes.

During the DESIRE project the gaps in educational offers were established using a 'Matrix of Gaps' specifically developed for the project. This gap analysis focussed on the topics of inclusive design theory, basic physiological needs of (older) people, architectural and design requirements in the built environment, advanced and assisted technologies, social atmosphere and wellbeing, and the inclusive human-centred approach. Although there were significant differences between the four participating partner countries (Portugal, Slovakia, Slovenia, and Spain), the main gaps in education offers in these areas could be concluded as followed:

- "Lack of a culture of accessibility, due to insufficient knowledge, denial of its need in specific sectors, inexistence or scarcity of regulations that require compliance or lack of consideration of the end user in the process.
- Persistence of outdated models with respect to accessibility or attention to disability.
- Lack of interest, involvement and / or preparation of the teaching staff.
- In some cases where Universal Design and D4All are being effectively applied in the classroom, there are also barriers to give them visibility and a separate identity" [96].

In order to create a deeper understanding of the value of responsive environments, further research is needed on the impact that smart building technologies have on the lives of the occupants and how this can help society as a whole. In addition, education offers need to reflect recent knowledge on inclusive design and accessibility, and more awareness is needed on the importance of these topics.

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5 Ethical assessment

This chapter will identify the ethical requirements and needs that have to be taken into account when building and working with a framework for the implementation of smart responsive environments. The general aim of this ethical assessment is to ensure that the social innovation framework takes into account the necessary legal, ethical and gender aspects towards excellence. These topics will also be incorporated in D5.2 – Gender and ethics management plan and report (see §1.2).

According to an article on ethical analyses of smart city applications, there are three types of ethical concerns: **data concerns, societal concerns, and implementation concerns**. Data concerns are technological challenges about the use of personal data, societal concerns revolve around the potential discriminatory effects of appliances or policies, and implementation concerns have to do with the implications of implementing smart solutions on a large scale [97]. An elaboration of the three types follows below.

5.1 Data concerns

5.1.1 Data privacy

One of the ethical issues that needs to be considered when building responsive environments is the use of personal data and how to protect the privacy of users. Personal data includes data about the identity of an individual, as well as sensitive information about this person, such as cultural background, political opinions, religious beliefs, health condition, sexual preferences, or potential criminal records [54]. Article 5 of the GDPR describes the eight principles relating to the processing of personal data, which need to be followed when any data is gathered. According to the GDPR [98] personal data should be:

1. "processed lawfully, fairly and in a transparent manner in relation to the data subject ('**lawfulness, fairness and transparency**');
2. collected for specified, explicit and legitimate purposes and not further processed in a manner that is incompatible with those purposes; further processing for archiving purposes in the public interest, scientific or historical research purposes or statistical purposes shall, in accordance with Article 89(1), not be considered to be incompatible with the initial purposes ('**purpose limitation**');
3. adequate, relevant and limited to what is necessary in relation to the purposes for which they are processed ('**data minimisation**');
4. accurate and, where necessary, kept up to date; every reasonable step must be taken to ensure that personal data that are inaccurate, having regard to the purposes for which they are processed, are erased or rectified without delay ('**accuracy**');
5. kept in a form which permits identification of data subjects for no longer than is necessary for the purposes for which the personal data are processed; personal data may be stored for longer periods insofar as the personal data will be processed solely for archiving purposes in the public interest, scientific or historical research purposes or statistical purposes in accordance with Article 89(1) subject to implementation of the appropriate technical and organisational measures required by this Regulation in order to safeguard the rights and freedoms of the data subject ('**storage limitation**');

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6. processed in a manner that ensures appropriate security of the personal data, including protection against unauthorised or unlawful processing and against accidental loss, destruction or damage, using appropriate technical or organisational measures (‘**integrity and confidentiality**’).”

And:

7. “The controller shall be responsible for, and be able to demonstrate compliance with, paragraph 1 (‘**accountability**’).”

Then there is a separate provision, which in many cases is counted as the eighth principle: “Any **transfer of personal data** which are undergoing processing or are intended for processing after transfer to a third country or to an international organisation shall take place only if, subject to the other provisions of this Regulation, the conditions laid down in this Chapter are complied with by the controller and processor, including for onward transfers of personal data from the third country or an international organisation to another third country or to another international organisation.”

As was also concluded in the INTER-IoT project (see §3.3.4), the principle about ‘integrity and confidentiality’ is the most relevant for smart living environments, since it requires the embedment of a decent security system against unlawful access of personal data. Secondly, information needs to be available for users as to which devices collect which data and what it is used for (principle 1). Furthermore, the right tools need to be provided, enabling developers to follow the GDPR principles themselves. When integrating IoT-technologies in smart buildings the list of actions developed during the ethical assessment of the INTER-IoT project [54] should be considered:

- “Controlling access to the […] systems […] is necessary to allow users to determine who can access what data and how it can be utilized.
- A history including the source of data, modifications to data, and viewing of data is necessary to ensure that proper usage is controlled.
- Providing the tools so a user can ensure that they are collecting the correct data and the data is being used only for the purposes necessary to allow appropriate data management for processing of health and personal data.
- Providing the tools to ensure data can be isolate within the system so no other users will know about it or a description of it is necessary.
- Allowing users to manage how their data is seen, provides a way to ensure data is processed appropriately and ethically.
- Access to data needs to be controlled on a per user basis. […]”

5.1.2 Dataveillance and geo-surveillance

The use of data is necessary in smart city solutions, but it brings about an ethical question about the tracking of individuals, either through the use of personal data (dataveillance) or their location (geo-surveillance). Dataveillance occurs through the increased use of Personally Identifiable Information in systems and services, while geo-surveillance is done through e.g. GPS systems, CCTV cameras, or personalised transit cards. To ensure individual privacy, the anonymisation of such data is crucial. This can be done by re-identifying personal data with pseudonyms, a relatively simple computational technique, although one that might need to be legally enforced. By replacing personal information with a unique identifier, personal privacy can

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be maintained without compromising systems and services that rely on data-use. Even better would be a complete de-identification of data, by also removing the unique identifiers, to prevent the reverse engineering of personal data [99].

5.2 Societal concerns

5.2.1 Technocratic policy making

One societal concern revolves around the risk of technocratic policy making in the European smart city approach. Technocratic governance can be defined as the procedure by which "all aspects of a city can be measured and monitored and treated as technical problems that can be addressed through technical solutions" [100, page 9]. Calzada [25] argues that current smart city policies are becoming more technocratic than democratic in two ways: by prioritising economic value generated through Public-Private-Partnerships and by increasingly using algorithms to find stakeholders (see also §2.2.5). By not questioning the business models of strategically chosen stakeholders and the priorities they choose to set while developing smart cities, policy making is at risk of not being citizen-focussed yet claiming to be so. The use of AI then further marginalises minority stakeholders. Therefore, when creating an SI ecosystem, it is important to incorporate a multi-stakeholder approach, and include civic groups, like social entrepreneurs, intermediaries, and activists, bringing socio-political awareness and democracy back into the mix.

5.2.2 Data-driven urbanism

Another societal concern is the increased use of big data in urban development. As opposed to data-informed urbanism, which is based on smaller surveys, data-driven urbanism is based on a vast amount of real-time data continuously being gathered through private systems, such as transport services, financial institutions, social media, and home appliances. With the use of urban big data infrastructure and city systems can become interconnected, improving the efficiency and effectiveness of these systems, and providing citizens with a highly responsive city environment. The downside of this data-driven urbanism, however, is that human actions are massively objectified and reduced to numbers; this is called datafication. In reality big data cannot fully represent human needs and the complex multifaceted system that is an urban environment. By letting big data influence policy choices a technocratic governance is created (see §5.2.1) and at the same time, it brings privacy concerns through dataveillance and geo-surveillance (see §5.1.2). In order to create a more inclusive and multi-level smart urban environment, information from big data systems needs to be complemented with other forms of knowledge, such as smaller surveys. In addition, citizens should have more control over which data is shared and for what purpose [99].

5.3 Implementation concerns

5.3.1 Guidelines and protocols

Standardised guidelines and protocols, and in some cases new laws, are needed for the large-scale implementation of smart city solutions. If regulations are not up-to-date, new technologies could lead to functional errors, communication problems, integration delays, or misuse.

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According to an ethical analysis of smart city applications, the following implementation issues need to be considered:

- **Conforming services**; when integrating utility services such as energy systems, water supply, crowd control, and emergency response, conformity is needed to enable real-time exchange between service providers and therewith prevent distribution loss or misconduct.
- **Scalability**; the ICT infrastructure must be capable of handling the growing networking demands. Outages or communication errors could occur if technologies are not updated properly. Also, regulations are needed for arranging equal access to smart systems, especially when they are at risk of scarcity due to growing needs. Lack of regulations may lead to misuse by companies, such as providing services only to the highest paying customers.
- **Application procurement and organisational collaboration**; up-to-date procurement processes are required to ensure projects are not delayed due to legislation and lack of incentives, and ethical conduct is needed to ensure collaborations between organisations when implementing new projects.
- **Data ownership**; it is necessary to have clarity on who owns the data that is collected by smart devices and with whom it may be shared.

5.3.2 Autonomous devices

Clear guidelines are needed about the ethical software programming of devices. Artificial Intelligence is becoming increasingly important in the creation of responsive environments, but there are ethical dilemmas a machine is unable to make and therefore needs to be programmed to do so. A well-known example is that of self-driving cars; if an accident is unavoidable, who or what should it be programmed to crash with [97]? There are no right answers for ethical dilemmas such as this one, but when incorporating autonomous devices into smart buildings and cities an evaluation is needed of what choices a device should be allowed to take.

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6 Conclusions and recommendations for building the Social Innovation Framework

Based on the methodologies, standards, and good practices of previous SI projects (§3.4), the gap analysis (chapter 4), and the ethical assessment (chapter 5), responsive environment initiatives should be:

- **User-centred & Expert-driven**; with a bottom-up and top-down approach through co-creation workshops with experts, key informants, policy makers, primary end-users, and other stakeholders (caregivers, organisations, and businesses).
- **Value-driven & Multi-level**; value-driven instead of market-driven, by including a multi-stakeholder approach and a *glocal* perspective. Both quantitative and qualitative data are necessary to avoid datafication and to ensure a more inclusive and multi-level smart environment.
- **Accessible to a wide range of people**; technologies and services should be affordable, interoperable, available (open-source), understandable (user-friendly), and inclusive (Design4All). International collaboration between stakeholders is essential in this.
- **Implementable & Sustainable**; ICT should be capable of handling increased networking demands, regulations should be updated, and implementation should not be hindered by procurement processes. Innovations should be eco-friendly and cost-effective, and financing schemes, quality management, and population density should be considered during development.
- **Replicable & Scalable**; integrated smart solutions should be made in such a way that they can be reproduced and adapted to different environments and operating systems, and adhere to different policy schemes and territory-specific standards and needs.

The preferred mode of knowledge production for this approach is **mode 3**, which calls for the existence of multiple separate innovation frameworks that are in a balance of cooperation and competition (*co-opetition*) on both a global and local (*glocal*) level. This would increase interdisciplinarity and diversity, be more democratic than technocratic, and allow for the construction of a much wider variety of innovation initiatives. However, current policies do not fully accommodate mode 3 innovation production as of yet. Most KBEs still use economic-based models, which are inadequate for the growing need for more sustainable development [20]. Policy needs to support public, non-profit, and private actors, shifting the focus to the social aspects of SI (§2.1).

Even though structural changes in policies would be most beneficial for the creation of a large-scale SI ecosystem (see §2.1), a clear framework for implementation can improve collaboration between local ecosystems and foster transnational SI initiatives. In §2.2 an overview was provided of the different helix-frameworks that were conceptualised over the years. Projects completed between 2015 and 2022 most often used the quadruple helix model for their innovation scheme, but with the increasing pressure of the public towards 'eco-friendliness' more recent initiatives also incorporate the environment, as described in the quintuple-helix framework (see §2.2.4). It must be noted that in literature the concepts 'quintuple-helix' and 'penta-helix' are often used interchangeably. The quintuple-helix framework (as described by Carayannis & Campbell [23]) is more widely accepted and more referenced, and with good reason; with the growing importance for a socioecological transition of our society and

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economy, eco-friendly design should form an integral part of any innovation idea. This model was therefore also chosen for the SIRENE project during the proposal phase.
Nonetheless, the penta-helix framework (as described by Calvada [25]) covers decidedly important issues as well, especially when it comes to smart city development, because of its multi-stakeholder approach and focus on user-centrism, implementation, and replicability. Including a wider range of stakeholders and sectors, such as social innovators, entrepreneurs, and activists, has proven beneficial in making smart city solutions more sustainable (see §3.4.2), which is a vital part of building age-friendly responsive environments.
At the same time, the neo triple-helix framework, even though it is still a conceptional model, also raises valid points. This framework incorporates all the elements of the quintuple-helix framework but rethinks the theoretical grounds of all the helices and tries to clarify their interrelations, while highlighting the transnational nature of innovation ecosystems. Because current SI ecosystems are scattered in nature using territory specific policies (see §3.4.3), a focus on transnational collaboration could help in bridging local biomes and creating global standards. In addition, there seems to be a fundamental problem with envisioning the institutions of the triple helix on the same level as concepts such as public opinion, the media, and civic society (the fourth helix) and the environment (the fifth helix).

Ideally a combination of the neo triple- and penta-helix models is used for the SIRENE project, incorporating interrelations between ecosystems, eco-friendly design, and sustainability, as well as citizen-focussed replicable development and diversity in choice. For this reason, a new helix framework was constructed; the **Transnational Local-sphere model** (Figure 22). This model puts more focus on stakeholders, organisations, and underrepresented entities, is user-centred by using a bottom-up approach, includes (trans)national collaboration and competition (*co-opetition*), is *glocal* by integrating global and local ecosystems, and involves civic society, through the media and the public. By using the Transnational Local-sphere model the SIRENE solution will try to connect existing local SI ecosystems and create a trans-sector network of stakeholders to ensure an accessible and sustainable result for its users.

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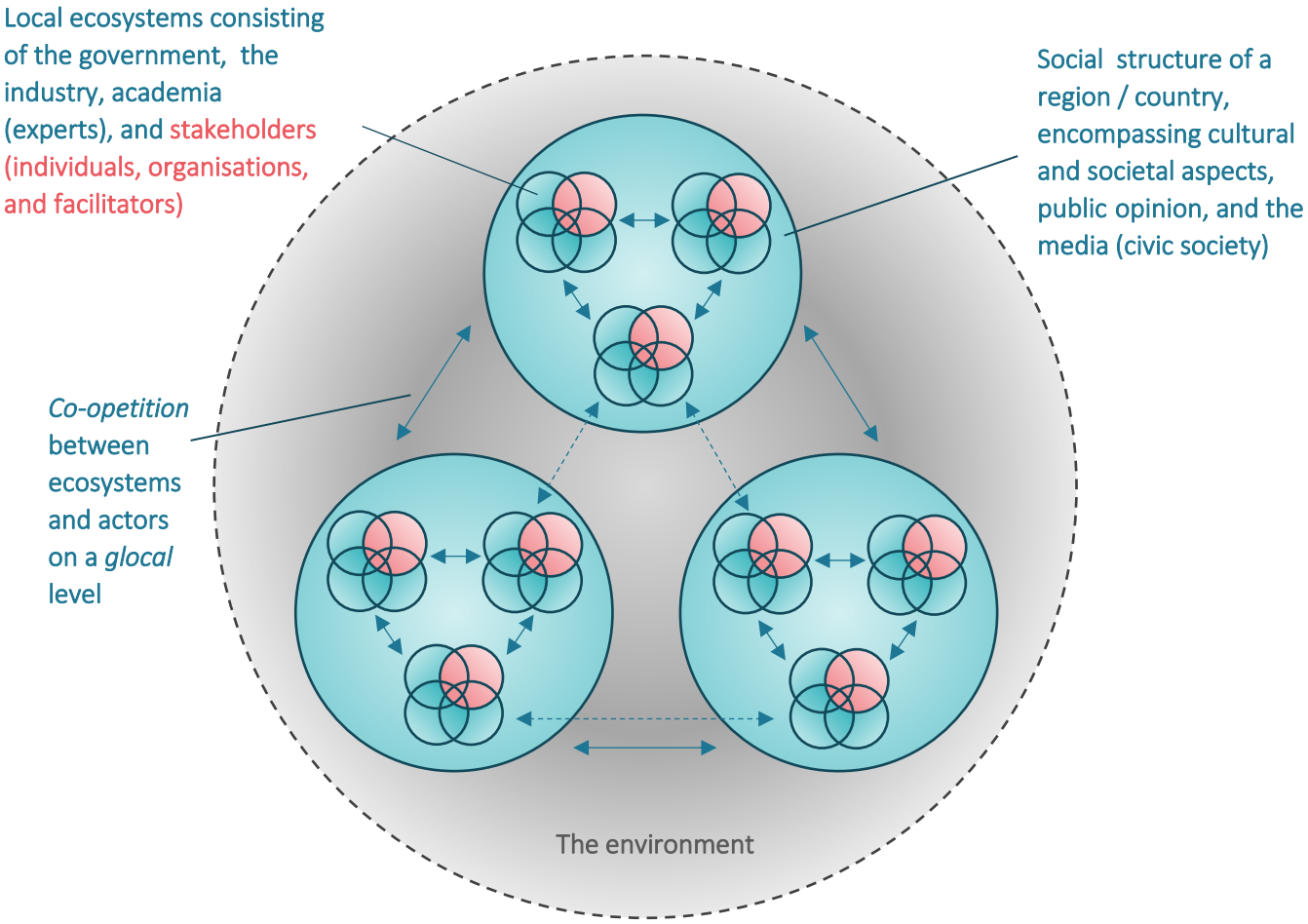

Figure 22. The Transnational Local-sphere Model that will be used for the SIRENE project.

The Transnational Local-sphere Model will form the base of the SIRENE Social Innovation Framework. It supports the identification and roles of the stakeholders, it provides insights into the elements of the environments that should be considered, and it demonstrates the relations between actors and institutions of various regions. As mentioned in §1.2, the SIRENE SI framework will consist of a manual, a capacity-building framework, a hands-on toolkit, a sustainability strategy, and a blueprint of good practices. The Transnational Local-sphere Model will be the theoretical foundation for all of these tasks, but will be especially useful for the construction of the manual for innovation actors. The manual, which will feature SI methods and concepts for the promotion of responsive, inclusive, eco-friendly environments, will be built on the results of this state-of-the-art review and will incorporate the ecosystem approach, transnational spanning, and *glocal* perspective of the Transnational Local-sphere Model.

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Annex I Glossary

Concept	Definition
Adaptive	"to explicate any alteration in the surrounding environment and to respond to it" [37, page 345].
Age-friendly city	"An age-friendly city encourages active ageing by optimizing opportunities for health, participation and security in order to enhance quality of life as people age" [31, page 1]
Intelligent	"those elements that "know" what the environmental conditions are both outside and inside, that "decide" how to provide a convenient and comfortable environment for occupants, and that "respond" promptly to occupant requests [33].
Interactive	"[A] system that fundamentally requires human input to initiate response" [39, page 86].
Responsive	"how natural and artificial systems can interact and adapt" [36, page 3]
Smart building	"buildings which integrate and account for intelligence, enterprise, control, and materials and construction as an entire building system, with adaptability, not reactivity, at the core, in order to meet the drivers for building progression: energy and efficiency, longevity, and comfort and satisfaction. The increased amount of information available from this wider range of sources will allow these systems to become adaptable, and enable a Smart Building to prepare itself for context and change over all timescales" [34, page 98-99]
Smart city	"A combination of an intelligent use of IT systems allowing to actively manage different areas of urban activity with the potential of institutions and active engagement and creativity of the citizens" [32, page 67].

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Annex II CORDIS database search results chapter 2.3

Project acronym	Record Number	ID	Title	Start date	End date	URL
IMPETUS	237007	101037084	Dynamic Information Management Approach For The Implementation Of Climate Resilient Adaptation Packages In European Regions	1-10-2021	30-9-2025	https://cordis.europa.eu/project/id/101037084
InnWater	242921	101086512	Promoting social INNovation to renew multi-level and cross sector WATER governance	1-3-2023	28-2-2026	https://cordis.europa.eu/project/id/101086512
MAPS-LED	194342	645651	Multidisciplinary Approach to Plan Smart Specialisation Strategies for Local Economic Development	1-4-2015	31-3-2019	https://cordis.europa.eu/project/id/645651
REPLICATE	200256	691735	REnaissance of Places with Innovative Citizenship and TEchnolgy	1-2-2016	31-1-2021	https://cordis.europa.eu/project/id/691735
RESIST	243790	101093968	Regions for climate change resilience through Innovation, Science and Technology	1-1-2023	31-12-2027	https://cordis.europa.eu/project/id/101093968
RIPEET	232240	101006295	Responsible research and Innovation Policy Experimentations for Energy Transition	1-2-2021	31-1-2024	https://cordis.europa.eu/project/id/101006295
TExTOUR	231941	101004687	Social Innovation and TEchnologies for sustainable growth through participative cultural TOURism	1-1-2021	30-9-2024	https://cordis.europa.eu/project/id/101004687

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Annex III CORDIS database search results chapter 3.2

Project acronym	Record Number	ID	Title	Start date	End date	URL
ACROSSING	198322	676157	Advanced TeChnologies and PlatfoRm fOr Smarter ASsisted LivING	1-1-2016	31-12-2019	https://cordis.europa.eu/project/id/676157
ACTIVAGE	206513	732679	ACTivating InnoVative IoT smart living environments for AGEing well	1-1-2017	30-9-2020	https://cordis.europa.eu/project/id/732679
ALHTOUR	199021	692311	ASSISTED LIVING TECHNOLOGIES FOR THE HEALTH TOURISM SECTOR	1-1-2016	31-12-2018	https://cordis.europa.eu/project/id/692311
Homes4Life	220227	826295	Certified smart and integrated living environments for ageing well	1-12-2018	28-2-2021	https://cordis.europa.eu/project/id/826295
City4Age	199899	689731	Elderly-friendly City services for active and healthy ageing	1-12-2015	30-11-2018	https://cordis.europa.eu/project/id/689731
IDIH	222560	826092	International Digital Health Collaboration for Preventive, Integrated, Independent and Inclusive Living	1-5-2019	30-4-2022	https://cordis.europa.eu/project/id/826092
INTER-IoT	199587	687283	Interoperability of Heterogeneous IoT Platforms	1-1-2016	31-12-2018	https://cordis.europa.eu/project/id/687283
MoveCare	206414	732158	Multiple-actOrs Virtual Empathic CARgiver for the Elder	1-1-2017	31-3-2020	https://cordis.europa.eu/project/id/732158
RADIO	194112	643892	Robots in assisted living environments: Unobtrusive, efficient, reliable and modular solutions for independent ageing	1-4-2015	31-3-2018	https://cordis.europa.eu/project/id/643892
REMIND	207045	734355	The use of computational techniques to Improve compliance to reminders within smart environments	1-1-2017	31-10-2022	https://cordis.europa.eu/project/id/734355
SCOTT	210798	737422	Secure COnnected Trustable Things	1-5-2017	31-10-2020	https://cordis.europa.eu/project/id/737422
SmartWork	219018	826343	Smart Age-friendly Living and Working Environment	1-1-2019	31-3-2022	https://cordis.europa.eu/project/id/826343
sustAGE	219053	826506	Smart environments for person-centered sustainable work and well-being	1-1-2019	30-6-2022	https://cordis.europa.eu/project/id/826506
symbIoTe	199859	688156	Symbiosis of smart objects across IoT environments	1-1-2016	31-12-2018	https://cordis.europa.eu/project/id/688156

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