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**SUPPORTING SUSTAINABLE DEVELOPMENT USING MULTIPLE CRITERIA
DECISION AID: TOWARDS AN AGE-FRIENDLY SMART LIVING ENVIRONMENT**

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SUPPORTING SUSTAINABLE DEVELOPMENT USING MULTIPLE CRITERIA DECISION AID: TOWARDS AN AGE-FRIENDLY SMART LIVING ENVIRONMENT

Abstract

This chapter aims to contribute to a better understanding of how sustainable development (SD) can be supported in the building of age-friendly SLEs to meet the needs of an increasingly ageing population. The proposed holistic analysis framework enables regional stakeholders engaged in building age-friendly SLEs to analyse the identified conditions and practices facilitating and encouraging knowledge collaboration (KC) and knowledge sharing (KS) that are key determinants of knowledge management (KM) and decisive means in supporting SD. Drawing on multiple criteria decision-aid (MCDA) approach, the framework was developed by involving representatives of regional stakeholders, who are innovation actors of the Häme region's (Finland) quadruple innovation helix model, Quadruple Helix, into a collaborative decision-making process within two empirical studies. The pilot study provided a substantial background for a deeper exploration of multidimensional, complex research questions and context in the main study which utilised problem structuring methods and techniques such as strategic options development and analysis (SODA), cognitive mapping, nominal group technique (NGT), and multi-voting. Assuming a constructivist, process-oriented stance, the main study enabled the development of a more realistic analysis framework through the sharing and aggregating of stakeholders' expertise and experiences and the uncovering of the cause-and-effect relationships among factors related to the topic under study. Taking the form of a collective cognitive map, the framework was validated by both the regional stakeholders engaged in the decision-making process of the main study and two external experts, who represented business organisations building age-friendly SLEs. Both studies revealed senior citizens' genuine enthusiasm and motivation to be engaged in building age-friendly SLEs and the vast potential they have in developing collaboration and sharing their knowledge and experience with other stakeholders.

KEYWORDS: Sustainable Development, Knowledge Collaboration, Knowledge Sharing, MCDA, Age-friendly SLE.

1 INTRODUCTION

During recent decades, the changing age structure of the population with the growth in the number of ageing people is a worldwide demographic phenomenon. The rapid growth of the ageing population is observed in the majority of the European countries today. This process is very advanced also in Finland, and the country ranks among the five fastest ageing populations worldwide (United Nations, 2019). The share of seniors aged 65 years or older will increase from the current 20 percent to 26 percent by 2030 and to 29 percent by 2060 (Finnish Institute for Health and Welfare, 2020). The effects of demographic change are already being felt today. Virtually, every country in the world is currently facing common challenges of meeting the needs of ageing people, particularly in the provision of such living environments that enable them to continue living a comfortable, independent, secure and active life outside of any institutional care setting (United Nations, 2019). At the same time, it is expected that older adults and their families will take a more active role in controlling their own well-being and health by interacting with a vast array of digital devices and executing a range of tasks within their home and

community. Given the current needs and expectations of relevant parties, digital technology solutions that particularly promote health, well-being and independence are increasingly being found as a promising means of improving the quality of life of seniors (e.g., Czaja, 2015; Niehaves & Plattfaut, 2014).

Providing continuous activity and health monitoring, early detection of risk events and cognitive decline, home rehabilitation and physical activity advisors, social connection support, companions for outdoor activities, and many other services not only allow older people to sustain their independence and quality of life in their own homes, but may empower them to participate actively in managing their own health and well-being. The physical space where these services – enabled through the Internet of Things (IoT) and communication technologies – take place is known as the Smart Living Environment (SLE) for ageing well (Alliance for Internet of Things Innovation (AIOTI), 2019). Thus, the SLE for ageing well represents a living environment built by the integration of digital assistive technologies within the services requested by older adults for supporting health and well-being and extending independent living in their own homes as well as responding to the needs and expectations of the social welfare and healthcare sector. However, in Finland, one of the biggest current challenges is to build age-friendly SLEs that are integrated into the infrastructural (built environment), technical, financial, administrative and social network producing community-driven and customer-oriented services (Topo, 2015; Kurkela *et al.*, 2017). Although Finland’s government promotes the piloting of and experimentation with innovative solutions and the scaling up of successful experiments in all public services, there is a strong need for seamless and committed knowledge collaboration between all stakeholders – business, academia, society and government organisations – to make it possible to provide better products and services for improving the health and well-being of the community (e.g. Holopainen *et al.*, 2018). Collaboration is critical particularly between the elder care system, technology producers and senior citizens to support the positive attitudes of the latter towards technology and its acceptance as well as the quicker uptake of innovative solutions (Weck *et al.*, 2020).

Addressing the challenges of building age-friendly SLEs reflects the United Nation’s Sustainable Development Goal (SDG) 11 ‘Make cities and human settlements inclusive, safe, resilient and sustainable’, which stated in the 2030 Agenda for Sustainable Development (Agenda 2030) (United Nations, 2015). To support SD to meet the needs of urban development, local or regional governments are recommended to adopt integrated, multi-sectoral approaches to address sustainable urban development from a holistic perspective, ensure transparency, enable the role and engagement of citizens in planning by creating engagement mechanisms and opportunities, as well as participatory practices that can lead to collaborative governance, and foster opportunities and mobilise successful examples, such as citizens’ bottom-up initiatives for sustainability (Sulla *et al.*, 2020). Furthermore, the recent report of Organisation for Economic Co-operation and Development (OECD) provides action-oriented recommendations to guide policy makers to implement a territorial approach to the SDGs, for example: “*use the SDGs to address concrete local challenges*” and “*use the SDGs as a vehicle to enhance accountability and transparency through engaging all territorial stakeholders, including civil society, citizens, youth, academia and private companies, in the policy-making process*” (OECD, 2020, p. 21).

Importantly, the Agenda 2030 which aims to set the world on a path to transform the world towards sustainable development (Pisano *et al.*, 2015; Baker, 2016; Assunção *et al.*, 2020) calls specifically for enhancing “knowledge sharing” in sectors contributing to the achievement of the SDGs, and for cities and regions, this means that robust knowledge sharing (KS) among all regional stakeholders can be a driver for achieving SDG 11. In practice, none of these stakeholders can achieve SDGs in isolation

without collaboration and the sharing of knowledge learned through their development work and experience in solving joint challenges. Through KS practice, stakeholders can contribute to knowledge application and innovation (Wang and Noe, 2010) and minimise inefficient efforts and the wasting of scarce resources.

The Covid-19 pandemic has slowed down the progress of reaching the goals set in the 2030 Agenda for Sustainable Development (United Nations, 2021a). António Guterres, Secretary-General of the United Nations, states in the latest SDG report (*ibid.*) that the recovery of the global pandemic requires collective action for collaboration based on sound data and science to create more inclusive and equitable societies, which emphasises the essential role of well-functioning and robust knowledge management (KM) models even more. Therefore, collaboration and KS are perhaps the most essential means for promoting sustainable development to meet the needs of age-friendly SLEs.

In this study, collaboration that aims to advance synergies between all stakeholders' activities in building age-friendly SLEs and an exchange of knowledge and ideas on the most prominent research achievements and development challenges is viewed as knowledge collaboration (KC). In relation to KC, knowledge sharing (KS) is of increasing importance, and it means a practice through which the mutual exchange of stakeholders' knowledge, skills and experiences take place. Despite the widely acknowledged view that KS and KC are key determinants of KM and decisive means in supporting SD, the body of empirical research attempting to provide evidence on how KC and KS practices can be improved is inadequate. Recognising the importance of supporting SD to meet the needs of senior citizens for the age-friendly SLEs, the focus of this study lies on KC and KS between all regional stakeholders engaged in building age-friendly SLEs. From the perspective of practitioners and researchers, it is essential to support the regional stakeholders' self-assessment and decision making in facilitating KC and KS that foster the emergence of ground-breaking ideas, concepts and scenarios leading to sustainable and innovative products and services while building age-friendly SLEs.

Thus, the general aim of this study is to contribute to a better understanding of how KM can be improved in order to support SD and meet the needs of senior citizens with regard to age-friendly SLEs. In particular, the study sought to determine conditions and practices that facilitate and encourage KC and KS between all regional stakeholders engaged in building age-friendly SLEs. Additionally, a specific emphasis was placed on the engagement and contribution of senior citizens.

The research questions were investigated in the context of the Häme region, Finland, where regional stakeholders collaborate with the aid of the OSIRIS Interreg BSR project to address emerging challenges in meeting the needs of senior citizens for age-friendly SLEs as well as to advance the achievement of the 2030 Agenda for Sustainable Development. These regional stakeholders represent innovation actors of the quadruple innovation helix model, Quadruple Helix (QH), which is a concept emphasising broad collaboration in innovation between government, academia, industry, and civil society (Arnkil *et al.*, 2010). They play different roles from the regional policy-makers and managing authorities, public and private service providers in social welfare and healthcare, research and business organisations, to financiers and associations of senior citizens or end users.

From the methodological perspective, this study exemplifies a constructivist, process-oriented approach (Belton and Stewart, 2002; Bell and Morse, 2013), allowing the combination of quantitative and qualitative methods and techniques such as cognitive mapping, nominal group technique (NGT)

and multi-voting for problem identification, solution generation, and decision making. Cognitive mapping is particularly useful to enable multiple decision makers (*i.e.* regional stakeholders) to be brought together, contribute their diverse knowledge and expertise to approaching multidimensional research questions and the underlying complexity of decision contexts by representing the situation in a structured and visualised manner (Eden, 2004; Eden and Ackermann, 2004). In this study context, the literature reports no prior research on this methodological combination.

The structure of this chapter comprises the following sections. The next section discusses literature focused on sustainable development, end-user engagement, and the role of KM. Then, the methodological background is introduced. Section four describes the procedures and decision-making process to determine and structure complex issues that concern the problem at hand within the two studies. Section five presents the results of the main study and the section concludes with the discussion of limitations, theoretical implications and contributions to managerial practice.

2. SUSTAINABLE DEVELOPMENT AND KNOWLEDGE MANAGEMENT

In the Brundtland report (United Nations, 1987), SD has been defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. In 2015, the United Nations General Assembly adopted the 2030 Agenda for Sustainable Development, a set of 17 sustainable development goals (SDGs), which set out a 15-year plan to achieve the goals. Implementing the SDGs that address global challenges aims to build a better future for all people (United Nations, 2015). Thus, for example, the aim of SDG 11 ‘Make cities and human settlements inclusive, safe, resilient and sustainable’ is to renew and plan cities and other human settlements to provide opportunities for all, with access to basic services, energy, housing, transportation and green public spaces, while reducing resource use and environmental impact (Eurostat, 2021). SDG 11 connects to SLEs and senior citizens through its targets, which addresses such issues as supporting positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning, as well as the needs of those in vulnerable situations, such as senior citizens (Global Goals, 2021).

As sustainable development is meant to be the ultimate and most important global commitment for societies this century, it addresses environmental, economic and social aspects (United Nations, 1987; Giddings *et al.*, 2002) such as conditions towards improvements in the quality of life for all age segments of the population. Accordingly, SD is also about maintaining senior citizens’ activity and health, and developing effective solutions for ageing at home that are related to the design of the living environment (Grazuleviciute-Vileniske *et al.*, 2020) and age-friendly SLEs alike. Enhanced by digital assistive technologies integrated within the system of health and well-being services, SLEs can enable senior citizens to live more actively and independently in their own homes. There is already a range of digital devices and service solutions available on the market to help achieve this. Moreover, they are being widely used by ageing people for different types of healthcare and social support services (*cf.* Morris *et al.*, 2013).

Building an SLE is often viewed as a solution to societal problems and a common target of governments and businesses worldwide enabling seniors to continue living a comfortable, independent and active life outside of any institutional care settings (Weck *et al.*, 2020). According to Trivellato (2017),

building SLEs relates particularly to social sustainability, defined by McKenzie (2004, pp. 15–18) as a “*positive condition marked by a strong sense of social cohesion, and equity of access to key services (including health, education, transport, housing and recreation). [...] Social sustainability occurs when the formal and informal processes, systems, structures and relationships actively support the capacity of current and future generations to create healthy and liveable communities*”. Furthermore, Parjanen *et al.* (2018) highlight the essential role of socially sustainable innovation processes in building more sustainable communities worldwide. They claim that instead of focusing on the end result, the focus should be placed on socially sustainable innovation processes that are the processes of innovating supported by an open and interactive development approach, resident and user-driven involvement, communication, learning and feedback, and impact assessment.

In the regional level, the paragraph 80 of the United Nations’ Agenda 2030 (United Nations, 2015) highlights the importance of peer learning, through voluntary reviews, the sharing of best practices and discussion on shared targets, and welcomes the cooperation of regional and subregional commissions and organisations. Local and regional governments are thus asked to advance the mobilisation of a wide range of stakeholders, facilitating “bottom-up” and inclusive processes, and forming multi-stakeholder partnerships (United Nations, 2021b). Further, paragraph 89 (United Nations, 2015) calls on major groups and other stakeholders, including local authorities, to report on their contribution to the implementation of the Agenda. With that, United Nations’ Agenda 2030 closely connects to the Quadruple Helix (QH) innovation framework. In the QH approach, it is the users or citizens who own and drive the innovation processes (Carayannis *et al.*, 2015) by participating in the actual development work as well as proposing new types of innovations, which connect them with other stakeholders (Arnkil *et al.*, 2010).

In building age-friendly SLEs, it is the senior citizens who represent the key “bottom-up” end-users. The role of senior citizens in SD and building SLEs is crucial, because through offering versatile living experiences, information and expectations and participating actively in decision making, they contribute both issues that can affect them and their communities (*cf.* Tamminen, 2016; Tuckett *et al.*, 2018). In addition, end-users engaged in innovation processes benefit from a reflective approach, because they are engaged in an innovation process that fits into their everyday practices, as well as being able to reflect on their own knowledge creation and learning from their involvement (Ståhlbröst and Holst, 2017).

Knowledge is “*the most strategic resource*” (Roth, 2003, p. 32) and essential capital (Davenport and Prusak, 1998). It “*consists of information and know-how*” (Schrettle *et al.*, 2014, p. 79), it is acquired from lessons learned together with new ideas and concepts (UN, 2016), and is in the heart of sustainable development decision-making. Knowledge is an essential source of innovative initiatives and a key driver and indispensable prerequisite for the sustainable development of societies and directly associated with SDGs (Brandner and Cummings, 2017; Knowledge for Development Partnership, 2017, p. 1), as it is stated by Van Kerkhoff (2013, p. 82) “*sustainable development is a knowledge intensive process, but plagued by persistent concerns over our apparent inability to connect what we know with more sustainable practices and outcomes*”. Therefore, it is imperative to integrate the practices of knowledge management with the aforementioned socially sustainable innovation processes, while these processes not only depend on the availability of knowledge, but on the collaboration and KS across and between various regional stakeholders advocating for Agenda 2030.

KM is widely acknowledged as the most critical means for achieving SDGs (United Nations, 2016; Ulewich and Blaskova, 2018; Mikalauskiene and Atkociuniene, 2019). Bounfour (2003) defines KM as a set of procedures, infrastructures, managerial and technical tools, needed for creating, sharing and leveraging information and knowledge. Adopting KM allows synergies, cross-fertilisation, bottom-up and top-down, horizontal and vertical learning and sharing (Brandner and Cummings, 2017). The United Nations (2016) underlined the importance of KM that can be used as a tool for promoting collaboration, improving access to knowledge, bringing together the inputs of the various stakeholders involved in SD activities. KM can be achieved “*through promoting the creation, sharing and application of knowledge as well as through the feeding of valuable lessons learned and best practices into corporate memory*” (*ibid.*, p. 55).

Furthermore, to attain the United Nations’ Agenda 2030, the world must recognise the substantial need to embracing the culture of knowledge sharing across boundaries without barriers. The importance of cooperation and knowledge sharing in sustainable knowledge communities utilising accumulative knowledge has been highlighted by Mikalauskiene and Atkociuniene (2019). According to them, “*the sustainability in the context of knowledge management means the precise conversion of economic goals into knowledge goals, refusal of outdated knowledge, identification and maintenance of useful knowledge, preservation of people who have valuable knowledge, knowledge usage in infrastructures, unexpressed (implied) knowledge transformation into expressed concepts and models, encouragement of knowledge sharing*” (*ibid.*, p. 151).

In this study, KC means an activity that aims to advance synergies between people and an honest exchange of knowledge and ideas on outstanding research achievements and development topics (Wang and Noe, 2010; Faraj *et al.*, 2011). Knowledge collaboration and communication are closely related to building healthy knowledge ecosystems, as well as knowledge partnerships, which include different kinds of knowledge processes, such as knowledge sharing, peer learning, co-creation and innovation, application and preservation (Knowledge for Development Partnership, 2017). In the context of urban and regional development, strong, open and transparent local knowledge partnerships, contributing to the achievement of the SDGs, have been seen vital to the validation and localisation of global knowledge resources and approaches and helping knowledge exchange to be realistic, pragmatic, and anchored in local knowledge ecosystems (institutions, markets, cultures) (Knowledge for Development Partnership, 2017).

Against this background, in the context of developing age-friendly SLEs, knowledge collaboration and knowledge sharing, as key determinants of KM, can be regarded as essential elements to achieve progress towards achieving SDG 11 and a balance between the three sustainability pillars – environmental protection, economic development and social cohesion (UN, 1987; Giddings *et al.*, 2002).

3. MULTIPLE CRITERIA DECISION AID

To understand how KM practices can be improved in order to support SD and meet the needs of senior citizens with regard to age-friendly SLEs, there is a need for a holistic analysis framework of factors indicating conditions and practices that facilitate and encourage KC and KS between all regional stakeholders and improve their decision making. Given this complex research problem and its context,

structuring complex decision problems well and considering multiple criteria explicitly in decision making lead to more accurate and better-informed decisions (Belton and Stewart, 2002). Thus, in this research, when complex factors are necessary to be considered in order to select favourable alternatives, employing multicriteria decision analysis/aid (MCDA) approaches is pivotal. The diversity of MCDA methods and techniques necessitates reflection on the most appropriate method for the decision context at hand (Roy and Slowinski, 2013).

This research possesses many similar characteristics with those for which problem structuring methods (PSMs) have been developed (Rosenhead and Minger, 2001; Mingers and Rosenhead 2004). PSMs are flexible mechanisms for addressing complex problems and providing a richer view of the decision situation by representing it in a structured model for decision-making in developing innovative solutions (Mingers and Rosenhead 2004). They are particularly useful to enable effective support in different phases of the decision-making process when there is a need to address complex issues characterised by the presence of multiple actors, who often possess different perspectives and objectives, and even conflicting interests and uncertainties (Rosenhead and Mingers, 2001; Mingers and Rosenhead, 2004). The literature provides a range of PSMs (Mingers and Rosenhead, 2004) including, for example, the most well-known strategic options development and analysis (SODA) initially developed in the 1980s by Eden *et al.* (1983). Providing a means for managing process and content (Ackermann and Eden, 2010), “*Strategic options development and analysis (SODA) is a general problem identification method that uses cognitive mapping as a modelling device for eliciting and recording individuals’ views of a problem situation*” (Mingers and Rosenhead, 2004, p. 532).

Being an integral part of the SODA methodology, cognitive mapping is commonly used to identify ideas and structure the thinking of various decision makers with their own problem (Eden, 1988). Cognitive mapping facilitates the collective sensemaking and the structuring of complex decision problems in an easily understood way by supporting communication and stimulating mental associations (Ackermann and Eden, 2001; Kang *et al.*, 2012; Gavrilova *et al.*, 2013; Castanho *et al.*, 2019). Cognitive mapping thus can help individuals and groups to explore more systematically and thoroughly decision problems, and cognitive maps are visual representation tools used to assist decision-making processes. According to Ackermann and Eden (2010, p. 138) “*cognitive map’ is a model of the ‘system of concepts (or statements) used by a person to communicate the nature of the situation – the way they make sense of their world’*”, and Eden (2004, p. 673) defined it as “*the representation of thinking about a problem that follows from the process of mapping*”.

4. METHODOLOGICAL APPLICATION

The decision-making process to determine highly complex issues that concern conditions and practices facilitating KC and KS was conducted in two studies: (1) a pilot study; and (2) a main study, the latter being divided into two phases. Both studies involved representatives of the QH regional innovation actors of the Häme region. Data collection procedures of both studies were implemented in December 2019 at the premises of the Hämeenlinna University Centre of Häme University of Applied Sciences within the framework of OSIRIS Interreg BSR project.

Table 1 Summary of the results of the two focus groups

Key regional innovation actors	Senior citizens' engagement and needs
Companies & private services (architects, ICT, household appliances, security, taxi, maintenance and repair, real estate management, services centres)	Advice on the spot; appliance and operational safety; fire safety; applying financial support to renovations, elevators etc.
Financial services organisations	Assistance in money withdrawal and deposits; face-to-face personal service; information about different services available
City & municipalities	Supporting clinics for seniors (e.g., ICT support, peer support); traffic services, recreational activities, appointments to health services, electronic social services
Public transport providers	Assistance for choosing routes and timetables, waiting times, purchase of tickets, group tickets, personal service, accessibility, call services, carpooling, proactive traffic planning, encouraging to use public transport services
Real estate developers & construction companies	Participating in development of public premises (e.g., rooms & gardens) for the opportunities to meet different generations; community housing; age-friendly construction
Condominiums and their boards	Providing support to renovations and recycling solutions
Social Insurance Institution of Finland (KELA) & Tax Authorities	Providing support for personal services; accessibility support
Education institutions	Collaboration with student projects; social media training activities
Voluntary organisations (senior citizens' associations and other social networks: family, friends, neighbours) and parishes	Collaboration with cities & municipalities, parishes, and many regional innovation actors; voluntary work.

4.2. Main Study: Cognitive Mapping and Problem Structuring

The main study was carried out in two phases: (1) knowledge panel meetings; and (2) external validation sessions. The aim of the first phase was to bring together knowledgeable experts who represented QH regional innovation actors actively engaged and shared a broad understanding of the problems and concerns related to the building of age-friendly SLEs in the region. In the selection of the members for the two panel meetings, considerable emphasis was put on their heterogeneity in terms of professional expertise, which was accomplished by using the QH approach, and gender. However, the purpose of the expert selection was not to achieve representativeness (Bell and Morse, 2013; Ormerod, 2020) but to collaborate effectively and produce well-focused results while approaching multidimensional research questions with the underlying complexity of contexts. Following the suggestion made by Eden and Ackermann (2001, p. 22) (*i.e.* “*the consultant [i.e. the researcher or facilitator] will relate personally to a small number (say, three to ten persons)*” or “*small groups (ideally of 6–10 key individuals)*” (Eden and Ackermann 2004, p. 618)), a group of eight experts or panel members were recruited with an important condition for them to commit to participating in the whole decision-making process of the two knowledge panel meetings. Thus, during this phase, eight selected experts acted as decision makers representing researchers, product and service developers, financiers, and the local authorities involved in regional economic and business development, as well as the region's senior citizens' associations. Both panel meetings were process-oriented in nature and facilitated by one main facilitator or instructor and two assistants, each one lasting four hours.

During the first knowledge panel meeting, experts focused on how KM can be supported among the regional innovation actors. In practice, the panel members were given the challenge of determining conditions and practices that facilitate and encourage KC and KS, as well as benefits and barriers. The general aim was to create a collective cognitive map that sought to represent the researched complex issues through cause-and-effect relationships (Ackermann and Eden, 2001; Silva *et al.*, 2021), and therefore the following trigger question was introduced: “Based on your values and personal experience, how do you describe the ‘best’ way to support KM?”.

The SODA method (Eden and Ackermann, 2001) was applied to support collaborative decision making and enable all the decision makers to structure the problem during the panel meeting. The method assisted the process of making sense of the problem, identifying key goals, stakeholders, concerns, uncertainties, and so on, ensuring that each panel member had a clear understanding of the problem’s context and overall structure (Belton and Stewart, 2002), and could express their opinions from their own perspective. They generated and wrote down 331 ideas or decision criteria with the help of the “post-its technique” (Eden and Ackermann, 2001), using one post-it note for each criterion that were placed on a whiteboard by two panel assistants. The next task was to organise criteria by key areas of interest, thereby defining the central criteria clusters, identifying criteria that impact on KM and marking them by a minus sign (–) on their post-it notes whenever a negative cause-and-effect was identified. *Figure 2* presents a few snapshots of the panel meeting results.



Figure 2 Post-it notes representing identified criteria and respective clusters

The panel members identified and labelled six clusters, namely: (1) *Involved Innovation Actors*; (2) *Motives and Benefits*; (3) *Barriers, Issues and Limitations*; (4) *Improvement Actions and Initiatives*; (5) *General Skills, Capabilities, and Competences*; and (6) *Resources and Knowledge-based Activities*. Their final task consisted of creating a hierarchy of all the identified criteria within each cluster that means the organising of ideas on post-it notes by order of importance on the whiteboard, *i.e.* from top – the most important – to bottom – the least important. This was followed by discussions regarding the

most fundamental characteristics of age-friendly SLEs. Three strategic determinants were identified: “*Comfortable Life*”; “*Active Life*”; and “*Independent Life*”.

This visual representation of results on the whiteboard (see *Figure 2*) was particularly helpful for the following tasks in the decision-making process, because it required the full engagement of decision makers in structuring the problem at hand and generating a multiple criteria framework for the collective cognitive map. Once the basic structure of the framework was finalised and the first panel meeting was closed, the collective cognitive map was developed using the *Decision Explorer* software (www.banxia.com). *Figure 3* introduces the collective cognitive map, which contains all 331 identified criteria or determinants. The cause-and-effect relationships between identified criteria/determinants are shown by the arrows. Due to space limitations in this book chapter, it is not possible to present a clearer version of the map, but the general structure is visible. A larger version of the map is available upon request from the corresponding author.

The same group of eight decision makers participated in the knowledge panel meeting II. This meeting was dedicated to the validation of the developed collective cognitive map through analysis, discussion, and revision. The developed collective cognitive map was introduced to the experts, and they were invited to amend the map’s content (*i.e.* all criteria) and/or shape, if changes were considered to be essential and necessary. *Figure 3* displays the final or validated version of the cognitive map. While the development process of this map was particularly comprehensive in terms of knowledge and experience exchange, it was intrinsically subjective. Different maps could be structured by other experts and during longer time, for example. Therefore, it should be noted that “*there is less emphasis on the outputs per se and more focus on process: how the group members interact and what they learn about themselves from that interaction*” (Bell and Morse, 2013, p. 962).

Additionally, the second panel meeting consisted of the focus group discussion with a specific emphasis on the contribution of senior citizens. NGT and multi-voting were applied as structuring methods to obtain inputs from the experts, promote their active participation in the decision-making process, and facilitate the identification of common ground from different perspectives. Each panel member had the opportunity to present and defend his/her answer to the trigger question for 15 minutes. The trigger question in this second meeting was as follows: “*Based on your values and personal experience, how can senior citizens contribute to KC and KS among regional innovation actors?*”. No discussion was allowed during this 15-minute period to avoid interruptions and guarantee equal expression opportunities to each member. After the 15-minute period given to each panel group member, their answers were written on a vertical white board visible to everyone. An active group discussion took place at this moment to validate the individual answers obtained. In total, 21 initiatives and actions were suggested. Then, multi-voting was utilised in order to gain a ranking of scores assigned to senior citizens’ initiatives and practices that can contribute to the KC and KS among regional innovation actors building age-friendly SLEs (see *Table 3* in *Section 5*).

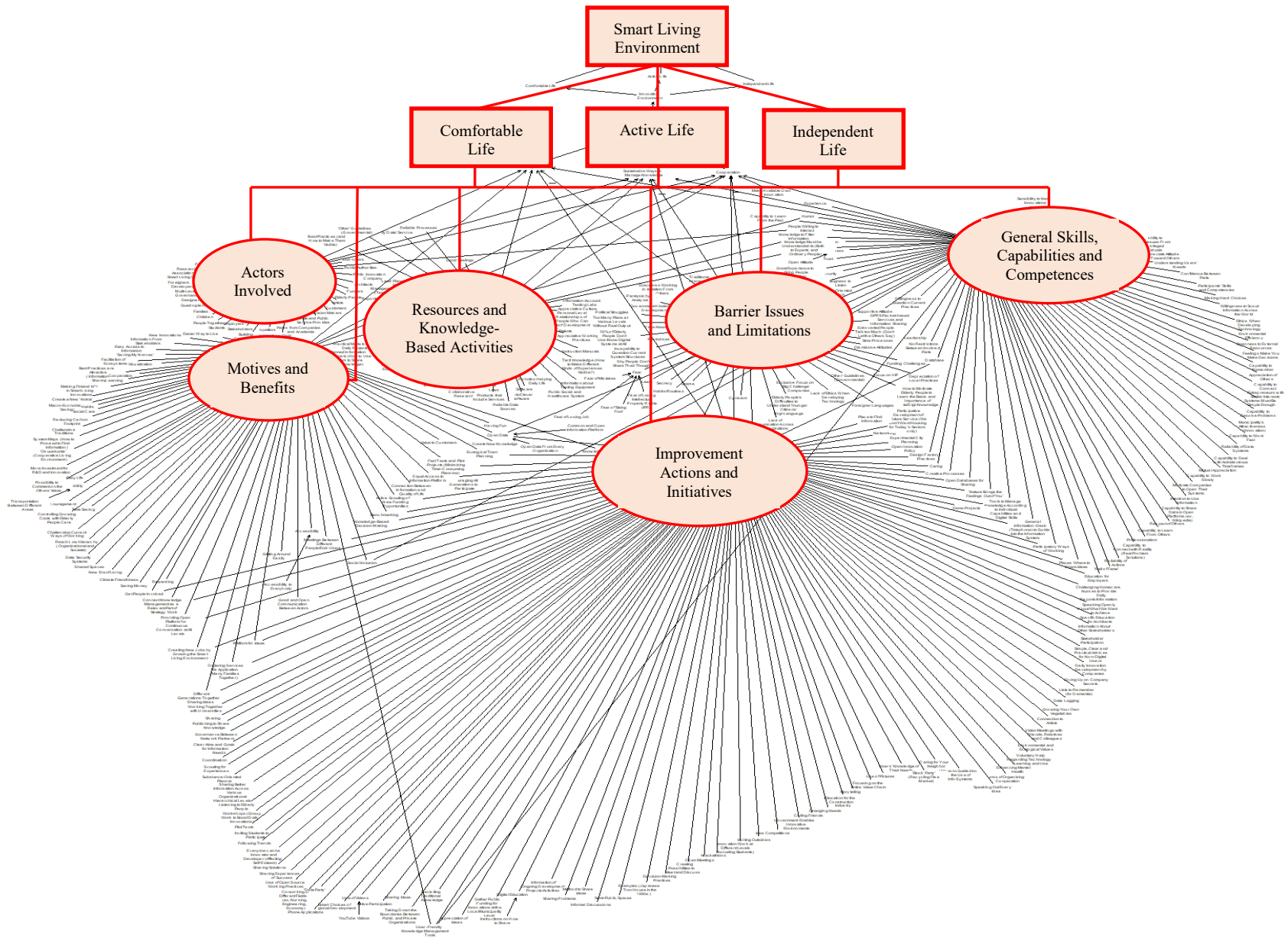


Figure 3 Collective cognitive map

The aim of the second phase of the main study was to validate the developed visual representation of consolidated results, *i.e.* collective cognitive map. Two interviews were held with external experts from two Finnish private business organisations from the Häme and Lapland regions of Finland, both directly engaged in building age-friendly SLEs. Having presented the results to the interviewees, the interview discussions focused on the following issues: (1) the comprehensiveness of the determined factors in the visual framework or cognitive map; (2) the representativeness of key groups of QH innovation actors or experts engaged in building age-friendly SLEs; (3) the transferability and generalisation of the results; and (4) the usefulness of the results' visualisation in future decision-making processes. Both interviews lasted for approximately one hour, audio video recorded and transcribed verbatim.

In the discussion about the framework comprehensiveness, both interviewees provided positive feedback, which is evidently reflected in the following interview quotation: *"The analysis is extremely comprehensive in relation to the time and resources available, and it definitely covers all viewpoints [...] One just cannot say that anything would have been left out"* (citing one of the respondents). Then, having been familiarised with the list of experts and their organisations who participated in the first two stages of the main study, the interviewees considered that the experts involved in the decision making and framework development work were competent and qualified, and represented the relevant organisations from academia, business, policymakers, and civil society or senior citizens' associations in accordance with the QH approach. Both interviewees were consistent in their point of view, saying that the experts were therefore able to generate heterogeneous ideas making a valuable contribution to decision making based on their diverse experience and expertise in the problems under analysis. One of the respondents described the representativeness as follows: *"All in all, there is a good representation of experts covering different fields, aspects, and viewpoints"*. The next issue concerned the generalisation and transferability of the results, and in the words of one of the interviewees: *"the findings are global and fully transferable at least in Nordic countries, which have rather similar cultures. In my opinion, a comfortable, active and independent life is the most important issue worldwide [in terms of age-friendly SLEs]"*. In addition, the other respondent highlighted *"the development level of the society that probably also determines and influences [the transferability and generalisation of the results]"*. Finally, both interviewees had rather similar opinions regarding the usefulness of visual representation of decision-making results, because it permits any practitioner to see very complex issues in one *"big picture"*. The visual representation *"brings out the motivators which make people act and where to they want to proceed, and guide to make decisions serving as many people as possible [...] and especially by zooming the visual map, also single issues can be distinguished and [the visualisation] becomes more beneficial and available"* (citing one of the respondents).

Overall, the results of this phase support a conclusion that data consolidated in the cognitive map are valuable and directly applicable by practitioners engaged in building age-friendly SLEs. However, the idiosyncratic results cannot be generalised for other contexts (*e.g.*, regions) without the necessary adjustments. Importantly, these interviewees did not participate in the two knowledge panel meetings with the QH representatives of regional innovation actors, and therefore, they were impartial reviewers of the study process and the results.

5. RESULTS ANALYSIS AND DISCUSSION

As it is recommended for sustainability researchers, the adopted methodology allowed to focus more attention on stakeholder participation (Olawumi and Chan, 2018). Representatives of the key QH regional stakeholders identified in the pilot study took an active role and participated as experts in the decision-making process in both knowledge panel meetings of the main study. The cognitive mapping technique combined with the SODA method enabled them to share and aggregate their opinions and experiences, and identify a total of 331 determinants or criteria of conditions and practices that facilitate and encourage KC and KS between all regional stakeholders engaged in building age-friendly SLEs. This technique permitted to create a holistic framework with cause-and-effect relationships between these criteria. The multi-criteria framework or collective cognitive map (see *Figure 3*) can support decision making in promoting sustainable development through KC and KS. The created six groups of criteria or clusters, their sizes, and examples of identified criteria (*i.e.* conditions and practices that facilitate and encourage KC and KS) are shown in *Table 2*, starting from the largest to the smallest cluster.

Table 2 Clusters, their sizes, and examples of identified criteria

Cluster / group of criteria	Size	Identified criteria / determinants (examples)
Improvement Actions and Initiatives	93	working with universities; inviting students to participate; listening to elderly people; sharing experiences of success; meetings with end users; sharing problems; sharing solutions; informal discussions; storytelling; idea competitions; pilot tests; participatory ways of working; encouraging all generations to participate; publishing to share knowledge; clear aims and goals for information needs; etc.
General Skills, Capabilities, and Competences	61	understanding users' needs; appreciated attitude towards others; open attitude; willingness to share; willingness to listen; willingness to question current practices; willingness to interact; capability to resolve problems; capability to address meaningful issues; receptivity to innovations; trust; reliability of actors; ability to filter information; etc.
Motives and Benefits	59	good & open communication between actors; easy access to information; controlling growing costs of the care of elderly people equal access to information platform; new era of living; easy life; climate friendliness; accessibility to everybody; social care; shared spaces; etc.
Barriers and Limitations	54	50% of elderly people do not use/know any digital systems at all; incapability to question current system structures; political struggles; funding challenges; fear of mistakes; prejudices; lack of communication across organisations; underestimation of local practices; dismissive attitudes; etc.
Resources and Knowledge-based Activities	33	technology for sharing; best practices; management models; testing labs; access to creative spaces; collaborative research; planned information channels; tacit knowledge; reliable data sources; reliable processes; instruction manuals; publications; reporting systems; laws; etc.
Involved Innovation Actors	31	public authorities; private & public service providers; building constructors; end-users; elderly people; researchers; designers; students; families; third sector; etc.

The size of the clusters indicates how many criteria are integrated into each cluster, and basically, it refers to the significance within the framework structure. The number of clusters and their sizes depict the complexity of the decision problem at hand.

In the created hierarchical structure, the largest group of criteria *Improvement Actions and Initiatives* is directly related to the main research question and suggest 93 identified conditions and practices that facilitate and encourage KC and KS to promote sustainable development in meeting the needs of senior citizens with regard to age-friendly SLEs. The next two largest groups *General Skills, Capabilities, and Competences* (in total, 61 criteria) followed by the *Motives and Benefits* cluster (in total, 59 criteria) were found to be closely connected with *Improvement Actions and Initiatives*, and may have a considerable impact on sustainable development in the region. The next largest *Barriers and Limitations* cluster with 54 criteria was determined as critical because these factors raised a lot of concern regarding the negative impact they may have on the criteria of all other clusters that are positive for sustainable development. The following clusters *Resources and Knowledge-Based Activities* and *Involved Innovation Actors*, with 33 and 31 criteria respectively, are at the core of the structure, and these identified criteria play a central role in screening and accelerating the uptake of innovative products and services for building age-friendly SLEs and cover various resources that fundamental to the effective KM implementation. Additionally, among the strategic criteria emphasised by the expert group, the criteria such as “*Comfortable Life*”, “*Active Life*”, and “*Independent Life*” were incorporated into the structure. These strategic criteria, corresponding to the meaningful characteristics of the age-friendly SLEs, were regarded as a common target of sustainable development for QH regional stakeholders, and therefore placed at the top above all the other criteria.

The final analysis focused on the engagement of the end-user or senior citizens’ group of QH regional stakeholders in the activities that contribute to KC and KS and lead to better decisions supporting sustainable development in the region. *Table 3* depicts a list of the engagement initiatives and actions that were proposed and prioritised according to the voting results of the experts participating in the panel meetings.

Table 3 List of the engagement initiatives and actions after the ranking of measures

Engagement Initiatives & Actions		Engagement Initiatives & Actions	
1	Taking part in the city planning	12	Participating in digitalisation as an active learner
2	Joining open discussion groups for end-users	13	Improving digital skills
3	Sharing ideas in the open innovation platforms	14	Providing “neighbourly” help
4	Interpreting the needs of “digi-passive” senior citizens	15	Allowing access to senior citizens’ personal data (medical data, etc.)
5	Supporting usability/user-centred design of products and services for senior citizens	16	Supporting easy way to get help for senior citizens
6	Supporting senior citizens to participate in pilots	17	Learning new methods of teaching and learning
7	Participating in innovation development activities	18	Accepting of innovative home-based services
8	Participating in decision making as an innovator	19	Joining discussion groups in senior associations
9	Gathering soon-to-be pensioners and students to co-create new solutions	20	Sharing own knowledge in social media
10	Introducing innovations to soon-to-be pensioners for their feedback	21	Providing peer-to-peer support when possible
11	Participating in idea exchange with voluntary sector		

The findings showed that having accumulated both vast professional and personal experience, and with more time at their disposal, senior citizens represented very motivated and enthusiastic actors willing

to be engaged in age-friendly SLE-related decision-making. The critical role of this group of stakeholders is confirmed by 21 well-focused engagement initiatives and actions through which senior citizens can contribute to the KC and KS in practice. These findings corroborate many different ways and levels of achievement successful stakeholder engagement acknowledged in previous research (*cf.* Bal *et al.*, 2013; Pellicano *et al.*, 2014; Rhodes *et al.*, 2014).

6. CONCLUSION

In accordance with Agenda 2030 for SD and specifically SDG 11, world leaders are being encouraged to work together with enhanced commitment to advance the quality of life for the most vulnerable members of societies (Global Goals, 2021; United Nations, 2021a). Thus, SD is also about maintaining senior citizens' active and healthy life and developing effective solutions for ageing at home that are related to the design of the living environment (Grazuleviciute-Vileniske *et al.*, 2020) and age-friendly SLEs alike. As it is widely acknowledged in the literature, in order to achieve SDGs that make up Agenda 2030, it is crucial to support KM, which is the most critical means for promoting collaboration, improving access to knowledge, bringing together the inputs of the various stakeholders involved in SD activities (*e.g.*, United Nations, 2016; Ulewich and Blaskova, 2018; Mikalauskiene and Atkociuniene, 2019).

The results and discussion presented in this book chapter shed more light on how KM can be improved to support SD in building age-friendly SLEs to meet the needs of senior citizens. The research specifically focused on identifying conditions and practices that facilitate and encourage KC and KS between all QH regional stakeholders engaged in building age-friendly SLEs with the emphasis on the engagement and contribution of senior citizens as end-users. Drawing on the MCDA approach, the collaborative decision-making process engaging regional stakeholders that represented the Quadruple Helix of the Häme region, Finland, allowed for the development of the holistic analysis framework in the form of the collective cognitive map. Given the idiosyncratic characteristics and subjective elements of the proposed framework due to a specific research context and diverse decisions made by representatives of QH regional stakeholders with various kinds of expertise and experience, any generalisations cannot be formed without a careful analysis and reasoning. However, the constructivist and process-oriented approach of the applied methodology permits the continuous making of adjustments and updates based on new information and knowledge (Ferreira, 2016).

By incorporating the identified conditions and practices facilitating and encouraging KC and KS that are key determinants of KM, the proposed framework enables regional stakeholders to make analyses and decisions for improving KM. This well-structured framework and multiple factors explicitly considered in the decision-making process direct stakeholders to more accurate and better-informed decisions (Belton and Stewart, 2002). In terms of theoretical contribution, this research extends the body of the highly specialised and limited literature on KM in the context of SD, providing new insights into the conditions and practices for improving KM through KC and KS between QH regional stakeholders. Although the findings are idiosyncratic in nature, in theory they can provoke further interest and serve as an important starting point for future research on the impacts of effective KM on SD in building SLEs. From a methodological viewpoint, the research contributions are two-fold. First,

the combined use of structuring methods and techniques (*i.e.*, SODA, cognitive mapping, NGT and multi-voting) made the authors believe that it is a novel approach for a deeper exploration of the multidimensional concept of KM in the complex SD context. The second comes from the description of the applied process, which allows for replications in different contexts and/or with different groups of involved stakeholders, due to the process-oriented nature of the proposed framework (Bell and Morse, 2013).

The research findings indicated that having accumulated both professional expertise and personal experience, and with more time at their disposal, senior citizens showed genuine enthusiasm to be engaged in building age-friendly SLEs and the vast potential they have in developing collaboration and sharing knowledge and experiences with other stakeholders. The engagement of senior citizens as the end-users' group of QH regional stakeholders in the activities that contribute to KC and KS may lead to better decisions supporting SD in building age-friendly SLEs. Therefore, the role of the growing mass of senior citizens in developed countries as one of the end-user groups whose contributions can support SD requires further attention among researchers.

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