Article

JIM
ISSN: 2183-0606
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Vol. 12, 2 (2024)
p. 197-218
AM: Aug/2024
SM: Feb/2024

Designing Sustainable Ecosystem Business Models in the Regional Context

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Abstract

From the perspective of innovation management, designing a sustainable business model for an ecosystem is crucial to ensuring value realization for ecosystem members and society in general. However, the current understanding of ecosystem business models is relatively limited. Based on a case analysis of a regional ecosystem, we provide new empirical evidence on ecosystem business models. In our case study of the water management ecosystem, we present its evolution since the 1980s and identify the key elements of the business model design. Our analysis indicates that ecosystem business models must consider regional characteristics and the dynamic nature of the ecosystem. This collective value discovery process is complex, necessitating that ecosystem leaders, orchestrators, and participants understand not only what and how value is created, but also what value supply-side participants derive from their voluntary involvement at each phase. The results can assist policymakers and ecosystem members in driving value capture through ecosystem business models.

Keywords: Ecosystem; sustainability; business model; water sector; case study

Cite paper as: Pellikka, J., Lähdesmäki, B., (2024). Designing Sustainable Ecosystem Business Models in the Regional Context, *Journal of Innovation Management*, 12(2), 197-218.; DOI: https://doi.org/10.24840/2183-0606_012.002_0009

1 Introduction

Clean water and water infrastructure including drinking water, wastewater, and stormwater are critical to modern societies. However, several fundamental challenges are experienced by the water industry worldwide including cost efficiency, higher demands from the multiple stakeholders, and capability to drive productivity and sustainability via digitalization (Anghileri et al. 2024; Goh and See, 2021). It has been seen that especially digital technologies such as 5G, Internet of Things, sensor systems and machine learning (ML) and artificial intelligence (AI) are transforming water industry. It is expected that these new capabilities can help water industry to unlock value capturing, productivity improvements and resource optimization as part of wider digital transformation across industries (Ghobakhloo et al. 2023; Kristoffersen et al., 2020). Due to these complex challenges, there is a need to change the traditional business models towards more ecosystem-based models that effectively integrates and commercialize the key capabilities from the multiple internal and external sources in the regional context (Collin et al. 2023; Stam and Van de Ven, 2021). Currently, water industry is incapable to build business models that can create the basis for the wider ecosystem collaboration for example with the cities, service providers, technology vendors and with the universities (Decker, 2023).

As pointed out, water industry ecosystems require a multiplicity of expertise encompassing digital transformation, data analysis, and connected technologies (UN, 2023). Thus, it is essential for utilities to establish ecosystem-based business models and partnerships with various organizations, with partners playing a wide range of roles in the digital transformation of water utilities, including providing technology solutions, offering expertise, and consulting services, and helping utilities develop and implement new operational strategies (UN, 2023). These ecosystem business models could allow participants to access the collective data assets, capabilities, and expertise needed to develop and commercialize new data-driven innovations and services (e.g. Palo and Tähtinen, 2011). To realize these benefits, understanding the ecosystem life cycle and orchestration of the ecosystem are essential elements to ensure the realization of the value for the ecosystem members. However, ecosystem business model is still an unknown research area both in terms of how they create value for companies and how they are orchestrated, and therefore need both scholarly and practitioners' attention (see e.g. Autio, 2022; Giudici et al. 2018). Based on the perspectives described above, this case study is focusing on the life cycle phases on water technology ecosystem since it was established in 1980s. In addition, our objective is to describe the activities conducted during each phase and their impact on the ecosystem business model.

Therefore, our aim is to answer the following key question:

> *What are the building blocks of an ecosystem business model in the industry-specific context during the ecosystem life cycle phases?*

The paper is organized as follows. Section 2 discusses previous literature related to the key elements of an ecosystem business model. Section 3 describes the methodology, and the collected data and data analysis of a conducted longitudinal case study of water ecosystem. Section 4 presents key results and finally, section 5 summarizes the key implications and avenues for the further studies.

2 Literature review – Identifying building blocks for ecosystem business models

Ecosystems are organizational collectives combining forces to create value offerings to a defined audience. Since the introduction of the concept 'ecosystem' in the business context (Moore, 1993), the concept has been studied from multiple perspectives covering for example strategic management (Adner, 2017; Dedehayir et al. 2018), innovation and platform (Thomas and Ritala, 2022; Hein et al., 2019; Gawer and Cusumano, 2013), and entrepreneurial (Attour and Lazaric, 2020; Pellikka and Ali-Vehmas, 2019). Compared to the other concepts including 'innovation clusters,' 'innovation systems,' 'innovative milieu,' and 'value network,' ecosystems can be distinguished from other community constructs through their participant heterogeneity, role of digitalization and platforms, type of system-level output, variety of participant interdependence, and nature of governance (Möller et al. 2020; Thomas and Autio, 2020; Pellikka and Ali-Vehmas, 2016). In addition, research has identified ecosystem offerings as malleable and users as having a broader range of opportunities to define the value offering compared to the context of conventional supply chains (Autio, 2022). In terms of water industry, growing importance of ecosystem collaboration has been also underlined (see e.g. Ateia, 2024; Lyu et al. 2021; Brisbois, and de Loë, 2017) highlighting especially needs to build robust models and practices for value creation in the innovation ecosystem context. In this paper, we define the term 'innovation ecosystem' as follows 'An innovation ecosystem is a community of hierarchically independent, yet interdependent, heterogeneous participants that collectively generate a coherent, ecosystem-level output and related value offering targeted at a defined user audience (Thomas and Autio, 2020). To capture value in this context, 'ecosystem orchestration' is needed where ecosystem leaders persuade others to make voluntary inputs that are consistent with the ecosystem's overarching value offering (Autio, 2022). In addition, we define the term 'ecosystem business model' as an agreement among ecosystem members to create and capture value for the ecosystem and society in a sustainable way (Oskam et al., 2021; Boons and Lüdeke-Freund, 2013). This definition also includes the key resources (i.e. the assets, such as people, technology, products, and equipment) required to deliver the value to the targeted customers and stakeholders, and the key processes including those required to run ecosystem activities and the operational and managerial processes.

In the ecosystem context, member organizations need to define business model that integrate different interests, which increases the complexity of designing one. Therefore, the key elements of ecosystem business model should be defined. Previous studies have shown that innovation ecosystems must have an articulated vision, a core purpose, and key objectives that remain relatively stable while the strategies and practices continuously adapt to a changing environment (e.g. Oskam et al. 2021; Autio and Thomas, 2018). It is highly important that vision building is intended to create a fundamental, ambitious sense of purpose, one to be pursued over many years. A collective vision-building can clearly indicate the long-term approach on how the ecosystem creates and captures value for the member organizations in the dynamic environment in which it operates (Guzman et al. 2024). This is because a vision has no power to inspire ecosystem members or attract new members to join unless it offers a view of a sustainable future. In addition, based on the articulated ecosystem vision, the decision-makers can create an ecosystem strategy, which is key to an ecosystem's operations (Adner, 2017). Finally, once the ecosystem has developed a vision of what market it wants to enter and with what offerings, it comes up with a tentative agreement on the performance expectations that enables it to reach the set objectives for value capturing.

Ecosystems can enhance their performance in a dynamic business environment by focusing on their dynamic capabilities (Heaton et al. 2019). Dynamic capabilities can help ecosystems to adapt to the emerging changes in the business environments. In addition, it can help to identify and develop innovation and business opportunities and, in general, to maintain competitiveness through enhancing, combining, protecting, and, when necessary, reconfiguring the organization's intangible and tangible assets together with the ecosystem partners (Linde et al. 2021; Möller et al. 2020). As previously pointed out, the industries and business environment are constantly forming and transforming through exploration, mobilization, and stabilization. Therefore, in the water industry, a broad environmental scanning of the emerging requirements, changes and opportunities is essentially needed. From this perspective, ecosystems must develop their capabilities to adapt and, beyond that, be complemented with sufficiently agile structures and processes. Building these types of capabilities also require decentralized decision-making and a collaborative organizational culture in the ecosystem (Heaton et al. 2019).

Ability to manage how the ecosystem create and capture value has been identified as another building block in the ecosystem business model. This is important not only the stand-alone value creation but also to ensure high quality of the assets created and integrated by other ecosystem partners during the ecosystem's life cycle (Rietveld et al. 2019). Although innovation ecosystems have been increasingly used by companies to foster innovation through collaboration, there are still challenges regarding how to successfully orchestrate ecosystems (Linde et al. 2021; Pikkarainen et al. 2017). It has been noted that one main challenge is to effectively orchestrate a network of actors, assets, data, and resources in the ecosystems (Collin et al. 2023; Möller et al. 2020). In addition, assets and resources must be orchestrated by a strong entity willing to take the lead of the further development (Heaton et al. 2019; Pellikka and Ali-Vehmas, 2019). Therefore, ecosystem management and facilitation are also crucial elements to realize value creation via e.g. transparent governance and the structured management practices with partners and complementors (Sjödin et al., 2024). In other words, it is crucial that ecosystems are managed and facilitated in a structured way based on the pre-defined, articulated governance model including the rules of the engagement and boundary resources (Attour and Lazaric, 2020; Hein et al. 2019; Jakobides et al. 2018).

Innovation ecosystems typically consider the complex and dynamic structure as they bring multilevel perspective and capture the complex relationships that are formed between multiple actors such as large companies, SMEs, start-ups, universities, government, NGOs, citizens, regional communities, infrastructure, customers, end-users, and other actors as previously discussed. To be successful in this context, i.e. to create and capture value in the ecosystem, organizations must develop explicit ways and processes to manage change (Marcon and Ribeiro, 2021). A specific need for change can be caused by the wide variety of drivers including market changes, legislation, emerging new technologies, standardization, and changes in the mutual adjustments inside the ecosystem or multidirectional influences between ecosystem actors and their ecosystem context (see e.g. Nylund and Brem, 2023; Jones et al. 2021; Autio and Thomas, 2018). From this perspective, it is essential that ecosystems can systematically develop key enablers of trust building among the ecosystem members including e.g. complementarity of obligations regarding the product life cycle, differing perceptions of obligation fulfillment, and balance between value creation, ecosystem objective, and overall mission (Foss et al. 2022; Benitez et al. 2020). Within this context, the main activities linked to change management can involve initiatives towards the key regional and national stakeholders and policymakers to proactively contribute to the continuous improvement of the business- and innovation-friendly environment and economic growth (Sant et al. 2020).

According to the previous studies, we can also see the linkage between innovation ecosystem emergence and ecosystem orchestration (e.g. Thomas et al., 2022). A better understanding of ecosystem emergence processes is important, since the presence of any regularities may help orchestrators and participants better anticipate how the ecosystem will emerge, thereby increasing the likelihood of success in value creation via ecosystem business. Since ecosystems are typified by complex systemic interdependencies (Adner, 2017), the role of the orchestrator and the decisions of the other key members are essential to manage this entity. From the ecosystem member point of view, they can adopt different forms of collaboration to develop future innovations for example, companies face a choice between taking an active or a passive role in the innovation ecosystem (Pellikka and Ali-Vehmas, 2016). If a member assumes a leadership role in an ecosystem, the member will have the opportunity to tailor the ecosystem's development in a way that may align closer to its own strengths and gains. Moving beyond conceptual models, recent scholarship has begun to provide empirical evidence on the phases of ecosystem emergence. Many of the previous studies discovered that ecosystem emergence typically follows a process including several key phases. For example, Sant et al (2020) showed that the main classifications related to the structure of an innovation ecosystem are the ecosystem life cycle (birth, expansion, leadership, and self-renewal), the classification according to the ecosystem level (macroscopic, medium, and microscopic). It has been proposed that the ecosystem follows the following main phases: 1) conceptual design; 2) ecosystem building; 3) operation and maintenance, and 4) succession (Tolstykh et al. 2020; Thomas and Autio, 2015). After succession, there are two possible reactions to the challenges: self-sustaining growth or retrenchment. From the architectural point of view, an effective ecosystem orchestration should entail orchestration activities in four layers: technological, economic, cultural-behavioral, and institutional (Autio, 2022).

Although established ecosystems have been studied widely, there have been only few empirical explorations of the processes of ecosystem emergence actions ecosystems could take to successfully foster value creation from inception to maturity (Yaghmaie and Vanhaverbeke, 2019; Giudici et al. 2018). Therefore, is it essential that an ecosystem must be able to identify in more detail the key value creation elements, drivers, roles, and key constraints (Leminen et al. 2012). It has been previously indicated that both the orchestrator(s) and the regional service infrastructure including innovation policy should provide a nurturing environment for the innovation ecosystem value creation in the regional context (Yun et al. 2017). In addition, it has been recommended that priority should be given to policies designed to promote co-creation and co-value capture via joint value discovery, collective governance, platform resourcing, and contextual embedding (Thomas et al. 2022). Through these, ecosystems can be created and establish themselves as functioning organizational collectives. To enable this, significant objectives of economic policies have been established to provide suitable infrastructure and enhance the availability of appropriate support for the ecosystems. However, it has been argued that studies should be more focused on identifying effective instruments and their integration within a wider support system and the optimal deployment of public policy to promote entrepreneurship and innovation (OECD, 2018). Thus, there is a need to examine the requirements of ecosystems and the ecosystem orchestrator(s) associated with the emergence process and to identify potential alternatives to help innovation ecosystems to reach their set objectives.

3 Research Design, Methods and Data

3.1 Research design

As highlighted in the literature review above, concepts and information from a large range of disciplines, such as business economics, organization theory, industrial relations, and innovation management studies need to be considered when examining the innovation ecosystem and its orchestration. Previous authors have reported that case study method can improve the relevance of management and innovation studies in the ecosystem studies, and they can provide valuable insights into innovation particularly from organizational, sociological, and managerial perspectives (de Vasconcelos Gomes et al. 2018). The longitudinal case study approach was chosen because it allows investigation of processes that evolve over time and is recognized to understand an evolving phenomenon within a real-life context in situations where there is little theory regarding those phenomena (Yin, 2018). In addition, the case study approach allowed in-depth investigations to be undertaken and to create interactions between theory and data during the study (Feagin et al. 1991). A longitudinal case design is appropriate for obtaining a deep understanding of the specific context, allowing exploration of ecosystem dynamics, performed efforts by an orchestrator and the relationship among the conducted effort. Studying the case over a long period of time further allows proximity to the nucleus of the case, and since we aim to understand multiple aspects on ecosystem business model by covering a long period of time in the ecosystem lifecycle, this would be possible to conduct with an in-depth study (see also Khurana and Dutta, 2021; Feagin et al. 1991). Our longitudinal study thus allowed a better understanding of the sequence of events and activities as they emerged. The data were collected by both authors who acted as a participant observer at the ecosystem for three years, as part of R&D research project. The summary of the research design can be described as follows (see Figure 1 below).

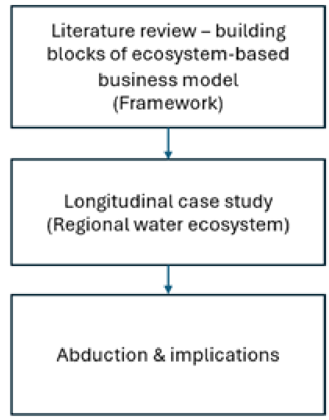

Figure 1. Summary of the research design

3.2 Research setting – introduction of the case Kuopio Water Ecosystem (Finland)

The case study focuses on the development of the regional water ecosystem (registered as Kuopio Water Cluster) since it was established 1980s. The mission of the ecosystem is to foster water-based research, development, and innovations, and to help companies and address water-related challenges. Since its establishment, Kuopio Water ecosystem facilitates the emergence of new businesses in the water expertise field (i.e. start-ups and new products and services) and strengthens the position and capacity of existing companies to achieve potential growth. Furthermore, KWC attracts new businesses to the region (i.e. spearhead corporations and SME) and supports the access to international markets for companies in the water management sector. The main technological focus areas are: 1) Development of water treatment technologies, recovery processes, and closed water cycles, 2) Prevention of water and groundwater pollution, agricultural water pollution, and industrial water management, and 3) Intelligent water management solutions and wireless technologies (incl. 5G technologies with the strategic ecosystem partners). In particular, the know-how is applied to the reduction of emissions from water-intensive industries (i.e. the mining industry and the pulp and paper industry), to the water supply of communities, and to the development of comprehensive management of the water impact in agriculture. Ecosystem offer the ability to develop and test new water technology applications in practice both in laboratory conditions and as pilots on field sites in cooperation with companies operating in multiple industries.

At the regional level, the organization of the ecosystem is based on the core members and their participation. Savonia University of Applied Sciences coordinates the Kuopio Water Cluster (www.kuopiowatercluster.com) in close collaboration with other key public and private organizations. Kuopio Water Cluster contributes to the development of new technologies, products and services for current challenges in the water sector, such as water treatment in the mining and pulp and paper industries and the digitalization of water supply. The solution is being developed in close cooperation with operating companies. Founding members include Savonia University of Applied Sciences (Savonia), University of Eastern Finland (UEF), Finnish Institute for Health and Welfare (THL), Geological Survey of Finland (GTK), Finnish Food Safety Authority, and Natural Resources Institute Finland (Luke). These organizations employ a total of nearly 200 water industry experts, mainly located in Kuopio's Savilahti area. At the core of the cluster are unique laboratory and pilot facilities for the implementation of operations, especially in pilot settings. Today, 70 organizations have joined the ecosystem.

3.3 Research data collection

Data were gathered from multiple sources that covered both in-depth, semi-structured interviews among the ecosystem members and other key stakeholders, and other documentation. The primarily data of the study is based on the conducted interviews with members from the Kuopio water ecosystem who have played a key role in the different phase of the ecosystem emergence and the current ecosystem collaboration. The interviewees were gathered with the assistance of the supervising group and all the identified candidates were first contacted via email and phone. Observations were used to obtain a holistic view of ecosystem's development since the establishment. In total, between 2021 and 2023, 15 interviews were conducted. The interviewees were selected according to the relevance of their roles and responsibilities concerning ecosystem development and management. Summary of the interviewees can be found in the Table 1 below. The roles of the interviewees included department head (ecosystem leader), program manager (key contributor), CEOs and CTOs from the member companies as well as other stakeholders from public and private sector.

Table 1. Background information on the interviewees and the organizations

Type of organization	Number of interviewees	Level of ecosystem experience (years)	Role in the ecosystem	Performance
University of applied Sciences	3	30+	Ecosystem leader	Research, development, innovation and education
University	2	30+	Member	Research, development, innovation and education
Research institute	1	30+	Member	Research
Research institute	1	20+	Member	Research and development
The Regional Council	1	25	Complementor	Regional innovation policy maker / regional developer
Ecosystem member (Small and medium-sized enterprise, SME)	1	20+	Member	Water technology developer
Ecosystem member (Small and medium-sized enterprise, SME)	1	20+	Member	Industrial IoT developer
Ecosystem member (Small and medium-sized enterprise, SME)1	1	15+	Member	Software developer
Ecosystem member (Small and medium-sized enterprise, SME)	2	10	Member	Water quality system technology developer

Type of organization	Number of interviewees	Level of ecosystem experience (years)	Role in the ecosystem	Performance
Ecosystem member (large company)	1	5	Member	Wireless technology developer
Ecosystem member (large company)	1	3	Member	Water technology consulting and technology developer

During the interviews, the interviewees were instructed to describe their role and the nature of the current activities in the water ecosystem since it was established. For example, informants were asked to share their views on the inter-organizational collaboration within ecosystem, how it works, what are the main challenges, and what have been the main milestones and activities related to ecosystem's capabilities to create and capture value. The semi-structured thematic interview questions have been presented in Appendix 1 related to the progress of both strategic and operational work of a water ecosystem. The interview topics included subjects such as the mission and vision of the ecosystem, key actors, and performed activities to create value and drive commercialization. We also asked for lessons learned and the experience of interviewees regarding success factors in innovation ecosystems. The outline of the themes was applied flexibly in the interview situation. At the beginning of each interview, the background of the study was briefly described to the interviewees. The length of each interview was between 45-90 minutes. Every interview was recorded and transcribed by the researchers. These transcripts provided the basis for the data analysis.

To validate the main findings from the conducted interviews, we also collected secondary data. Observations consisted of internal ecosystem meeting, participation in ecosystem's strategy building workshops and other internal meetings. Secondary data were obtained from various sources, including internal meeting documentation (annual status and project-specific reports), regional innovation strategy reports and external documents such as national and EU-level water industry reports. The combination of primary and secondary sources allowed us to triangulate the collected information by double-checking the results. Thus, observational, and secondary data provided context and validation for the interpretation of qualitative interview statements employing triangulation.

3.4 Data analysis

The first step in our data analysis was data reduction including the steps of selecting, clustering, abstracting, and transforming the documented interview transcripts into a usable form. These transcripts were categorized and labelled into the time-ordered matrixes, which were further complemented by including additional columns (e.g. for information on roles and inputs) that are commonly used in role-ordered matrixes (see Miles & Huberman 1984). The categories related to activities that the interviewees considered to be key milestones, and activities helped us to construct a timeline of the life cycle phases (i.e. ecosystem emergence). The timeline of the eecosystem's life cycle phases was triangulated with the collected data and documentation, which is summarized in the Figure 3. In addition, we asked the representative from the ecosystem leader who has been part of the ecosystem since the beginning to visualize a timeline picture that describes the key milestones, activities, decisions, actors, and their roles to validate the outcomes of the interviews. The next step of the analysis was to identify the relationships between the categories and themes., which were further refined using insights from the previous studies and the collected data from interviews and secondary sources.

The final step included activities to summarize the key conclusions and verification of the results. During this phase, the key results of the study were critically evaluated and verified. During this phase, we summarized the key findings and shared that with the ecosystem leader's representative for the final validation. Additionally, to identify similarities and differences compared to the literature review and the conducted case study, an explanation-building procedure was applied in analysis to acquire further insight into issues concerning the ecosystem's business model and the life cycle. By comparing the previous results and the results from this case study, it was possible to establish the range of generality of a finding or explanation and to elucidate the conditions under which that finding occurs. During this phase, we also conducted the critical evaluation of the performed data collection and methodological approaches. First, in our longitudinal case study, data were collected from multiple sources to allow triangulation (Miles and Huberman, 1984). Second, the results were also validated through two additional review meetings with the ecosystem leader representatives. However, it is still important to note that special characteristics of each ecosystem may limit the potential to generalize the findings of this study, which also create further avenues for the future studies on this field.

4 Empirical findings and analysis

The following section will describe the life cycle phases of the water ecosystem since it was created in the 1980s. In addition, the section will highlight the key building blocks to create and capture value.

Value discovery in the 1980s - The impetus for cooperation between research institutes. Research collaboration in the water ecosystem started in the Kuopio region (Finland) in the 1980s. The organization currently known as the Finnish Institute for Health and Welfare (THL) and the University of Kuopio (now University of Eastern Finland, UEF) began research into by-products of drinking water disinfection. By focusing on a joint effort to deliver a shared value proposition, ecosystem participants collectively attempted to deliver an output greater than any single participant could deliver alone. As one interviewee commented:

> *'The key is the mutual vision and shared value among the founding members to build the basis for the ecosystem collaboration'.*

This joint research led to multiple international publications as well as e.g. significant updates to the disinfection recommendations for the Finnish water supply sector. In addition to research activities, THL and the university also cooperated in teaching with THL experts acting as visiting lecturers in university courses and supervising students' theses and dissertations. Cooperation projects led by the University of Kuopio related to the implementation of chemical and later microbiological analyses also took place. Joint professorships were established between the organizations to further promote cooperation. The importance of these early steps was also highlighted by one founding member who indicated that:

> *'During the early phases, it was essential to identify and realize all the synergies that helped to drive the domain-specific R&D forward'.*

Collective governance in the 1990s.

During the 1990s, the region started to invest more on the selected focus areas as part of the regional innovation system development and for example the regional university of applied sciences (the current Savonia University of Applied Sciences) was established. At that time the first version of the joint governance body was introduced among the ecosystem members to accelerate for example the joint use of the regional research infrastructure, wider scale research collaboration on water technology the domain-specific entrepreneurship Coordination of these idiosyncratic investments was made possible via aligned governance and structures that enable ecosystem participants to better identify their value-adding roles in the ecosystem. From this perspective, this early level coordination and ecosystem governance was one of the key building blocks towards the ecosystem's business model. As several interviewees underlined:

> *'Governance and active coordination were clearly a key milestone to ensure the scalability of the regional resources'.*

> *'Coordinators role was crucial to overcome the silos among the research organization and companies'.*

In the early 1990s, the regional technology center was also established in region to promote science-based entrepreneurship and more active collaboration between private and public sector. The new physical facilities and R&D infrastructure enabled expansion of the joint R&D efforts to foster value creation based on the water technology expertise. within this comprehensive domain. These efforts to jointly develop key resources in the water management domain were essential steps towards developing the ecosystem's business model. In addition, the city of Kuopio took more active role in developing the infrastructure and innovation support and development services for science-based businesses and startups with the regional technology center. The EU membership (1995 onwards) enabled the utilization of EU structural funds for development activities, which was also an essential element of the ecosystem's business model and enabled the basis for the high-quality research and business development.

The master's degree program in Environmental Technology was established at Savonia University of Applied Sciences in 1998. The main content of the degree program related to water technology and community technology including also additional areas such as air protection technologies and waste management. At the same time, significant investments on the new water laboratory facilities were jointly started by the universities and the other ecosystem members also indicating the roles and the main responsibilities between the universities and other stakeholders.

'It was the first time when the key ecosystem members agreed to jointly define their scope of work on, and also openly share the content-related responsibilities'

Research platform resourcing

Major extensions of the local technology center also enhanced water, water chemistry, and other related R&D efforts. In practice, the first phase of the technology center expansion was completed in 2001 and the ecosystem's water laboratory started in a shared laboratory environment together with the key ecosystem members. At the same time, growing EU funding enabled acceleration of the R&D investments in the region and with the new role of the universities (i.e. stronger impact on society including businesses) to drive further R&D collaboration projects across the ecosystem partners. The first joint RDI projects of these three organizations were launched and it formed the basis for future innovation ecosystem performance and RDI project cooperation. At the same time, cooperation with the University regarding the teaching of laboratory courses started at the water laboratory. The practical implementation of the cooperation was also supported and facilitated by the key ecosystem members. In addition, the joint laboratory was utilized e.g. for dissertation research and master's theses. The regional development task and applied research activities were indicated to be as a statutory task for universities alongside teaching activities.

The EU Structural Funds periods started in full in Finland, divided into the following program periods: Program period 2000-2006, 2007-2013, 2014-2020, and 2021-2027. The first program period in the region included the search for funding for multiple themes and projects without a very strong visible and strategic linkage to the regional strengths. However, the regional level priorities started to change during the second program period 2007-2013 when the thematic programs started to emerge. Through the thematic programs, the aim was to outline a few key areas for the development of the region and the needs of companies, to which most of the funding for that programming period was allocated.

Contextual embedding to drive value capture further. The use of Structural Fund programs became more efficient, and the selected development priorities began to influence and sharpen the regional development activities. The role of the University of Applied Sciences as an ecosystem leader was significantly strengthened. Regional programs and development strategies were outlined in extensive cooperation with the Regional Council of Pohjois-Savo. The cooperation concretized regional specialization, which was steered by the guidelines of the regional program and strengthened by the channeling of regional development funding. ERDF funding strengthened selected areas of expertise and the capacity to develop them further within the ecosystem. This development culminated in 2018 when the application for funding for the water ecosystem was prepared under the coordination of Savonia UAS. It was preceded by the so-called preparatory funding, which enabled e.g. the benchmarking of European and North American water competence centers and visits to selected example sites. Based on these, the official ecosystem status and structure of the water ecosystem and the mission were also re-defined to drive even stronger the value creation and commercialization. This ecosystem structure was further defined by the relative absence of hierarchical, contract-based governance modes, which made it necessary for participants to discover not only what the consumer-facing value the ecosystem created, but also what value supply-side participants derived from their voluntary involvement in the ecosystem (see also Autio, 2022). Two CEOs of the small and medium-sized enterprises and ecosystem members pointed this out by indicating that: ‘Since 2015, ecosystem started to be more and more attractive for larger number of organizations due to the structured and professional way of working to enable concrete value adding elements’

> *‘For us being part of water technology experts is a vital for our business growth and new product development’*

During the 2020s, the water ecosystem enabled more systematic and coordinated operations and further development of a large-scale ecosystem. In addition, on top of the founding ecosystem members (n=6), the ecosystem was opened also for corporate members to join. The total number of the enterprise members is currently over 60 and it is growing. Today, especially industrial level testing and piloting activities as well as business cooperation forms the core of the ecosystem’s practical operations. The aim was to serve the needs of companies operating in the field and to solve e.g. water-related challenges arising from water-intensive industries. The water ecosystem received European Cluster Collaboration Platform (ECCP) certification in spring 2021.

The summary of the building blocks of an ecosystem business model can be presented as follows (Figure 2).

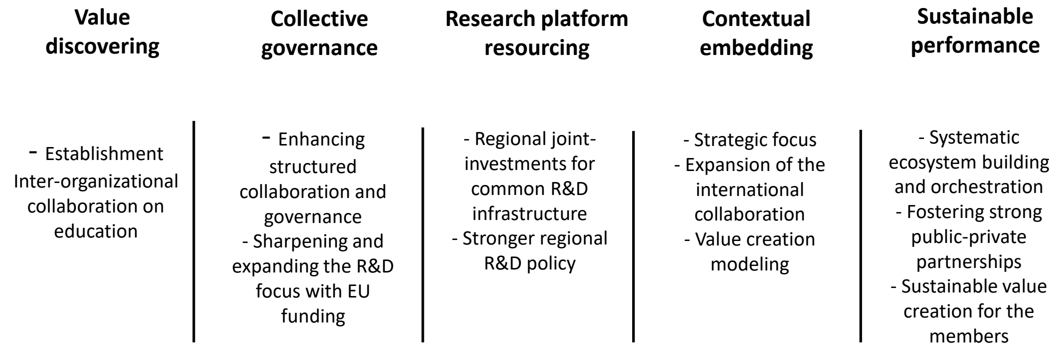

Figure 2. Ecosystem life cycle phases to create a sustainable business model

4.1 Building blocks of an ecosystem business model

Vision and goal setting. To ensure that ecosystem members behave in ways consistent with the ecosystem's vision, ground rules and a desired architecture of roles and value-creating interactions among these were defined especially in the 'value discovery' phase. It is also important to note that during the life cycle of the ecosystem, vision and goal setting have furthermore been reviewed during the later phases. One main objective of this joint visioning has been to identify the complementary elements of the ecosystem members (e.g. on education and R&D) as indicated in the case study, and to drive the creation and mobilization of valuable resources and assets via systematic planning of the activities. This result is aligned with the previous studies (see Autio, 2022; Thomas and Autio, 2020). All the planned efforts may help to reach the actual objectives of the ecosystem and to capture concrete value for the ecosystem members, external ecosystem stakeholders as well as the customers. In addition, it is also possible to foresee some challenges that may occur in different life cycle phases, and, as ecosystems evolve, the dominant challenges also shift, requiring managerial attention to shift accordingly (also Thomas and Ritala, 2022). Therefore, ecosystem leader needed to continuously monitor and proactively react to the potential changes and to be prepared to shift their focus of the activities during each phase of the ecosystem's evolution. Due to this, one key activity in the water ecosystem has been to define the ways to scout for new opportunities for the ecosystem and its members. Especially after 2019, the leading members have focused on the formation of a routine way of working to scan for opportunities that arise from emerging water industry, markets and technologies.

Industry and business environment. It has been noted that the context for value creation is changing in the dynamic business environment (see Möller et al. 2020). The results of the case study show that technological developments and increasing investments in the regional R&D infrastructure accelerated ecosystem collaboration and acted as one key of the ecosystem business model. In the water industry, organizations attempted to jointly share integrated sensor data to build a new kind of competitive advantage for example via new digital services, and decision-making support tools (Happonen et al. 2020). These actions could for example help to avoid pressure bursts in aging infrastructure (pipes, pumps, valves) that further cause leaks in distribution network leading to waste of clean water and reducing water safety. Thus, there is a growing need for smart water management to improve predictive control of water distribution, to increase water safety and optimize the efficient use of clean water in general. The business model responds to this need with a real-time monitoring system for water management to automatically detect and locate abnormal situations as leakages bursts based on the digital technologies. Further, the results indicate that regional contributions to the regional ecosystem are related to the underlying inter-organizational relationships, technological infrastructure, and availability of relevant knowledge inputs from the ecosystem members – all of which are simultaneously reinforcing determinants of a region's competitive advantage. These factors are especially important in the regional context when the ecosystem members are deeply embedded in the region, and, thus, are more dependent on the regional R&D infrastructure, business environment, and social networks (also Autio, 2022). Results also show that regional R&D infrastructure can contribute to ecosystem business models by providing a nurturing environment for joint R&D efforts and innovation activities.

Ecosystem management and governance. Based on the conducted case study, the results support the previous studies (e.g. Thomas and Ritala, 2022) by showing an importance of the shared ecosystem-level business models including e.g. value proposition and related value creation, delivery, and continuous improvement practices. Our results indicate that the governance of an ecosystem is one key element of an ecosystem's business model, and a governance model supports the value creation and capturing in the water ecosystem. Our case study also shows that the documented and executed governance of the ecosystem enabled shared use of the resources, data, and R&D infrastructure (e.g. water laboratory), and the preparation of joint-R&D projects. In addition, the results show that the chosen governance model became more essential especially when the ecosystem started to grow in terms of its members and volume of the R&D projects among the ecosystem members (see also Linde et al. 2021; Hein et al. 2019).

Based on the case study, we were also able to define that finding an optimal balance for the ecosystem governance model for the different and/or conflicting priorities among the members, control versus autonomy, is a challenging task for the ecosystem leader. The results of the case study also show that during the emergence, ecosystem leader need to persuade others to contribute voluntary inputs that are aligned with the ecosystem's mission, value offering, and business model (Autio, 2022; Leminen et al. 2020). This has required continuous adaptation to the evolving nature of the market, ecosystem, and its members' needs. Additionally, scouting emerging and cross-domain technologies, as well as the potential new entrants, has been required. Thus, having processes and routines that enable an adaptable organization to handle these needs and requirements have been necessary for ecosystem evolvement and performance. Therefore, we recommend that ecosystem leaders must be able to define the key areas in need of orchestration and understand the business model, as well as the related key activities to be performed at each phase of the emergence process. We also identified that the role of the ecosystem leader during the emergence process may change during the life cycle phases. For example, during the first phases of the water ecosystem evolution a strong R&D focus among the key ecosystem members was a dominating factor. During the later phases of the process, more focus was put on the institutional setting and institutional aspects, including continuous improvement of the ecosystem's capabilities to create value. This result is supporting the previous results (see Autio, 2022; Pellikka et al. 2022) and indicates that further understanding on ecosystem emergence and orchestration in the multi-layered context is needed.

Capabilities and complementary assets. Based on the conducted case study, the results support the previous studies (see e.g. Thomas and Ritala, 2022; Pellikka and Ali-Vehmas, 2016) that show an importance of the shared ecosystem-level business model including e.g. on value proposition and related value creation, delivery, and continuous improvement practices. The actual value capturing began to emerge when the leading ecosystem members started to systematically set mutual targets and initiate joint efforts on R&D to 1) *Improve cost efficiency:* Collaboration within the ecosystem enables organizations to obtain necessary skills and/or resources more quickly than developing them in-house for member's own individual use. In addition, when the water technology market changes rapidly, e.g. due to digitalization and wireless technologies, the ecosystem wants to avoid committing to and spending resources on fixed assets that may rapidly become obsolete, 2) *Accelerate commercialization of new solutions among ecosystem members:* For example, joint R&D infrastructure accelerated ecosystem members to develop, test, and validate their new R&D capabilities faster than before. Utilizing mutual capabilities within the ecosystem rather than building them in-house enables organizations to reduce its financial commitments and therefore foster ideation, leading to commercialization, and 3) *Expand market access:* Ecosystems have been focusing on creation of new water technology standards. Collaboration among the ecosystem members especially at the conceptual embedding phase can be an essential opportunity to ensure e.g. compatibility of a new solution towards the existing and new standards (see also Pellikka and Ali-Vehmas, 2019).

Monitoring impact and change management. During the life cycle of the ecosystem most essential change management situations are related to the expansion of the ecosystem. Since the number of ecosystem members started to rapidly grow especially during the 2020s, ecosystem coordination and operations required more orchestration and efforts to respond to the ecosystem member's needs. At the same time, the regional policy makers sharpened the regional development strategy and prioritized the key regional public investments based on the modern ecosystem thinking that created the basis also for the wider use of the joint R&D infrastructure and for expansion of the R&D project portfolio. Together with the increasing EU funding, these were the key factors to drive the Kuopio Water Cluster performance and operational improvement that was also more carefully monitored by the ecosystem as well as by the stakeholders. Our study supports the previous view where each ecosystem participant co-evolves with the other members and the investments need to be adjusted over time to maintain their complementarity (see Thomas and Autio, 2020). Orchestration of these investments also needed negotiations, agreements and, the decisions among the key ecosystem members as one change management activity.

5 Discussion and Conclusion

In this paper, we have presented both literature-based analysis and the empirical results of the key elements of the ecosystem business model during the ecosystem's life cycle. to create value for the ecosystem members. This collective value discovery process is complex, which makes it necessary for ecosystem leaders, orchestrators, and all the participants to discover not only what and how ecosystem can create value, but also what value supply-side participants derive from their voluntary involvement in the ecosystem in each of the ecosystem's life cycle phases. To support this view, we propose that the ecosystem orchestration strategy may be beneficial to define and execute the governance model to ensure value capturing in the ecosystem.

We propose that future research in ecosystem studies should focus on the concrete benefits to companies participating in multiple (instead of only one) ecosystems, as well as on the data-based view and knowledge flows between ecosystem members. This approach would help to increase our understanding on the different dimensions of the value co-creation by considering a larger number of perspectives among the ecosystem members (Autio and Thomas, 2020) in the different types of ecosystems. In addition, our study supports the previous results by indicating efficiency, innovation, and flexibility benefits are recognized as the sources of value in an ecosystem context (Thomas and Ritala, 2022; Thomas and Autio, 2015). Ecosystem members co-specialization, complementarity, and co-evolution together also enable the co-creation and appropriation of value. The institutional stability characteristic develops the importance of the locus of coordination, legitimacy and trust, and governance mechanisms. Therefore, we suggest that value creation logic, key resources, and key processes should be also in focus as part of the future studies to analyze these key elements of the ecosystem business model in other domain-based ecosystems, and to provide more systematic and coherent understanding of an ecosystem construct.

The results indicate that the systematic approach on innovation ecosystem management including ecosystem governance can drive value capturing via ecosystem business model. Our case study findings indicate that ecosystem emergence is a complex and multilateral process that involves at least a leader organization, ecosystem members, customers, and other stakeholders as previously discussed. This suggests that to design a value blueprint, the ecosystem leader must multilaterally negotiate what is 'valuable' and what the appropriate participant roles and individual-level value offerings are for the delivery of the ecosystem value proposition (see also Autio, 2022; Leminen et al. 2020). Finally, based on the analysis of the ecosystem emergence, we propose that previously highlighted multi-layered approaches together with the other innovation ecosystem development tools may be helpful framework for ecosystem leaders. Throughout an ecosystem's life cycle phases, ecosystem members face a choice between taking an active or a passive role in guiding ecosystem development. If an actor assumes leadership in an ecosystem, it will have the opportunity to tailor the ecosystem's development in a way that may align closer to its own strengths and gains.

Taking a less ambitious role naturally raises some key questions to answer including e.g. 1) which ecosystem leadership candidates to follow, 2) how to create valuable relationships with the selected candidate, and 3) what the sufficient level of the investment into the ecosystems is. The questions still require a clear understanding of the full ecosystem, its business model, structure, and dynamics for a successful ecosystem strategy (Leminen et al. 2020; Adner, 2017). Given the above considerations, policymakers at both national and regional levels should allocate resources at their disposal on ecosystem business model design to ecosystems and their orchestrators. In addition, the role of innovation policy underlines the importance of the legitimacy and embeddedness of the ecosystem in the broader economic and social context in which they operate (Thomas and Ritala, 2022). Therefore, these ecosystem-specific characteristics and external drivers may vary significantly across the ecosystems at the regional context, which is an important factor to consider in the future studies. Moreover, in the absence of unlimited resources, it is necessary to make regional choices between ecosystems to create the basis for the value capturing across the innovation ecosystems and their members. Further, before decisions regarding the allocation of regional resources can be taken, the policymakers need to know how they can efficiently support the emergence of ecosystems during the process directly and indirectly e.g. via ecosystem orchestrators. This requires knowledge of the emergence process and, for example, industry specific ecosystem business models including the identification of activities that orchestrators should and/or must do to drive further development and value capturing at the regional as well as the national and international level.

Finally, although this paper provides new empirical insights into the emergence of an innovation ecosystem and the key building blocks from one case study, it however does not provide generalizable results for the different ecosystem settings. Therefore, there is a need to carry out wider water industry and cross-industry studies to further expand the understanding of how ecosystems emerge and capture value. As we have primarily focused on ecosystem-level activities, our findings are limited to elaborate the firm-level performance on value creation as part of the innovation ecosystem. Thus, further research on the evolution of an innovation ecosystem would be very essential to provide useful insights for ecosystem leaders and other actors to make strategic choices in an ecosystem for value capturing.

Acknowledgement

The authors would like to thank the editor and two anonymous referees who kindly reviewed the earlier version of this manuscript and provided valuable suggestions and comments. In addition, we would also like to share our thanks to ISPIM conference participants in June 2023, the multiple professionals from the Regional Council of Pohjois-Savo, Savonia University of Applied Sciences and Kuopio Water Cluster for their valuable comments during the research project.

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7 Appendix

7.1 Appendix 1: Semi-structured thematic interviews

Section I: Background information regarding the entrepreneur and firm

1.1 **Interviewee's background information**

1. Could you please describe your work experience?
2. In what kind of organisations have you have worked before this assignment?
3. How long have you been working in this company?

1.2 **Firm background information**

1. Year of establishment:
2. Number of employees:
3. How long have you been working in this company?
4. Description of business activity:

Section II: Description of the ecosystem emergence & collaboration

1. Could you please describe in your own words how the water ecosystem was established?
2. What is your organization's role in the water ecosystem?
3. How would you describe the ecosystem emergence process in general?
4. What activities have been undertaken during that process?
5. Who were responsible for the commercialisation process in the firm?
6. Were there pre-defined spheres of responsibilities for these people during the commercialisation process?
7. Were external organisations or people involved in the commercialisation process?
8. What kind of roles did the ecosystem members play in the process?

Section III: The governance in the ecosystem

1. Could you please describe in general how the decision-making concerning the ecosystem's performance was structured and managed?
2. What kinds of decisions were made during the ecosystem emergence process?
3. What were the main purposes of these decisions?
4. Who were responsible for these decisions?
5. Does your firm have established practices for the decision-making during the commercialisation process?
6. What kind of internal or external information was used for the decision-making during the commercialisation process?
7. If external information was used, why and how it was acquired?

Section IV: Value creation in the ecosystem emergence process

1. Could you please describe in general what factors had the biggest positive or negative impact on value creation in the ecosystem, and why?
2. How ecosystem managed these factors?
3. When did these factors appear during the ecosystem emergence process?
4. Could you please describe what kind of resources value creation requires in the ecosystem?

5. Could you please describe what kind of services were used during the ecosystem emergence process?
6. What service was the most important for the process, and why?

7.2 Appendix 2: Time-Ordered Matrix

Time-Ordered Matrix

Interviewees (n=11 organizations)	Value discovering Duration:	Collective governance Duration:	Research platform resourcing Duration:	Contextual embedding Duration:	Sustainable ecosystem performance & business model Duration:
Organization 1 Name: Role: Main activities: Benefits: Challenges:					
Organization 2 Name: Role: Main activities: Benefits: Challenges:					
Organization 3 Name: Role: Main activities: Benefits: Challenges:					
Organization 4 Name: Role: Main activities: Benefits: Challenges:					
Organization . . . 11 Name: Role: Main activities: Benefits: Challenges:					

Biographies

Jarkko Pellikka. Jarkko Pellikka leads Nokia's Veturi programs and has extensive expertise in technology research, innovation ecosystems, and the commercialization of innovations. With years of experience as a senior leader in global multinational companies, as well as working with startups and SMEs, he has been responsible for driving and developing numerous strategic business operations and major initiatives in high-tech industries. His insights and experiences have been featured in various international scientific journals and books.
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Bailey Lähdesmäki. Bailey Lähdesmäki has extensive experience researching and facilitating the development of innovation ecosystems in both vertical and horizontal industry domains. Her focus is on co-created value provision for ecosystem stakeholders as well as sustainable operational models accounting for stakeholder types, roles, and capacities. With a background in scalable service design, international business, and innovation management, she cultivates multi-disciplinary opportunity identification and innovation valorization. Ensuring alignment between innovation ecosystems and place-based development needs and strategies, in connection with international policies and initiatives, is a cornerstone that drives her research and its practical application.
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