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# **Embedding non-industrial private forest owners in forest policy and bioeconomy issues using a Living Lab concept**

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## **Abstract:**

International policies have set sustainable development goals that put emphasis on bioeconomy strategies based on renewable resources. The forestry sector, by providing bio-based products, is expected to take part in this bioeconomy with, among other things, the reduction of society's dependence on fossil fuels. Nevertheless, in Europe, the forestry sector is facing an increase in the number of small private forest ownerships, called non-industrial private forests (NIPF), where wood mobilization is difficult due to both ownership fragmentation and the lack of interest of non-industrial forest owners in existing forest-wood chains. Although many policy instruments have been put in place to address this situation, the problem persists for two main reasons. First, a lack of use of policy instruments by forest owners and second, a lack of collaboration between stakeholders. To provide solutions, we propose a methodology to design territorial projects with non-industrial forest owners in the framework of a Living Lab innovation process. This paper presents both the general method developed and analyzed through open and user-centered innovation concepts and its practical implementation in the Vosges department in France. Our results show how the Living Lab approach can improve the acceptance, adoption and use of policy instruments by NIPF owners and how it promotes multi-stakeholder collaborations to design and deploy innovative solutions. The main interest of our study is to provide a methodology to pilot a forestry Living Lab for policy makers and practitioners, based on rigorous concepts of innovation management. Finally, future developments and limitations of our study are discussed in a global research perspective.

**Keywords:** Living Lab, Action research, French forest policy, wood mobilization.

## **1. Introduction**

The 2015 Paris agreements and the 2030 Agenda have set sustainable development goals that require the implementation of strategies to promote the development of a bioeconomy based on renewable resources (Bröring et al., 2020; Ladu et al., 2020). The bioeconomy would be one of the European Union's responses to the ecological, energy, food, climate, etc. challenges. (European Commission, 2012; Hansen and Bjørkhaug, 2017; Imbert, 2017). In particular, the development of the bioeconomy means a change in economic production that would lead to a substitution of fossil resources with renewable raw materials (European Commission, 2016). The bioeconomy encompasses the production of renewable biological resources, it includes agriculture, forestry, food production, pulp production, chemical, biotechnology, energy industries, etc. (European Commission, 2012). The forest-based sector, by providing bio-based

products, contributes to the development of the bioeconomy with, among other things, the improvement of society's dependence on fossil fuels (Geng et al., 2017; Nabuurs et al., 2013). Nevertheless, on a European scale, the forest sector is facing an increase in the number of private forest owners, leading to the formation of increasingly fragmented forest plots (Schmithüsen and Hirsch, 2010; UNECE-FAO, 2020). These fragmented plots, also known as Non-Industrial Private Forest (NIPF), represent a great potential for the forestry sector to enhance its response to bioeconomy strategies as they host a large wood resource to be mobilized (Lawrence, 2018). NIPF are the very small size properties which creates a multitude of difficulties in mobilizing wood (landlocked plots, high operating costs...) (Pezdevšek Malovrh et al., 2017; Orazio et al., 2017; Rauch and Gronalt, 2005; Stern et al., 2013). This results in difficult forest management (Lawrence, 2018; Weiss et al., 2012) and sometimes even total absence (Petucco et al., 2015), which leads to under-exploitation of timber compared to organic production (Levers et al., 2014). It should be noted that policy-makers and the forest sector have expressed great concern about fragmented private forests, particularly because of their low intensity of forest management and high diversity of ownership (Lawrence, 2018; Pezdevšek Malovrh et al., 2017). It has become necessary to classify these owners according to their current or expected management behavior (Ficko et al., 2019). Thus, researchers then began to develop typologies of private forest owners (PFO), also known as typologies of Non-Industrial Private Forest owners (Harrison et al., 2002). This resource cannot be mobilized because of numerous constraints linked to these fragmented plots, such as the lack of profitability of the plots, difficulties of access, lack of interest on the part of owners in forest management, etc. (Orazio et al., 2017; UNECE-FAO, 2020). However, for many years, policy makers and the forest sector have been trying to mobilize this resource through various measures in the form of financial incentives, regulatory and legal frameworks, owners' cooperatives, funding and material inputs, technical and governance interventions, etc. (Pezdevšek Malovrh et al., 2017; Orazio et al., 2017; Rauch and Gronalt, 2005; Stern et al., 2013). However, there is no doubt that these measures and all the efforts that have been associated with them for many years have not fully resolved the problems of wood mobilization in fragmented private forests (UNECE-FAO, 2020; Forest Europe, 2015). Several studies have identified the reasons for the failure of all these efforts (Orazio et al., 2017, Lawrence, 2018). We would like to focus on two main reasons very often cited by authors: On the one hand, a lack of use of policy instruments by owners (Danley, 2019). And on the other hand, a lack of collaboration between stakeholders to design and deploy policy instruments (Lawrence, 2018). Faced with this situation, which has existed for many years, researchers, policymakers, and practitioners have expressed a strong need for innovation to try to solve this problem (Orazio et al., 2017; Živojinović et al., 2015). On the basis of these two main reasons and given the expressed need for an approach to innovation, we propose in this study to direct our research towards approaches to innovation that could address this problem. First, regarding the lack of use of policy instruments by owners, we believe, as in the study by Arnould et al. (2021), that owners should be integrated into the process of designing policy instruments and that the design should take into account their needs and opinions. To do so, innovation through uses and user-centered design approaches allow users to be integrated early in the innovation design process in order to understand their needs so that the products and services designed will meet them (Von Hippel, 2001, 2005). Second, regarding the lack of collaboration between stakeholders to co-construct policy instruments, open innovation based on sharing and collaboration (Chesbrough, 2003) would allow stakeholders to collaborate and share their skills and knowledge to achieve a common goal (Chesbrough and Bogers, 2014). In the literature, there is a new innovation approach called the "Living Lab," which lies at the intersection of open innovation and user-centered innovation (Schuurman, 2015). Living labs began to develop in the late 1990s at the Massachusetts Institute of Technology (Eriksson et al., 2005). In Europe,

the debate on Living Labs began in 2006 when the European Commission (EC) funded projects to create policy measures that would advance, coordinate, and promote a common European innovation system (Dutilleul et al., 2010; Veeckman et al., 2013). In the same year, the European Network of Living Lab (ENoLL), which aims to address Europe's declining economic competitiveness and societal challenges, was established (Mastelic et al., 2015; Ståhlbröst, 2013). Consequently, the concept of Living Lab would seem to be adapted to answer the described problem. Thus, based on our context, we will try to answer the research question: How can the Living Lab approach improve wood mobilization in non-industrial private forest in response to bioeconomy strategies?

In this study, we propose a generic methodological reference framework for piloting forestry Living Labs in order to prove the relevance of this approach to address forestry issues. More precisely, this methodological framework will be adapted to answer our research question concerning the forest bioeconomy. Our methodology will be part of an action research, a form of research associated to the Living Lab concept, allowing for both scientific and practical contributions (Chiasson et al., 2008; Ståhlbröst, 2008). Thus, we will show how we designed our methodology as well as the results associated with it through its implementation in the Vosges department in France. Our article will be structured in several sections. Section 2 will present the theoretical part on the Living Lab approach. Section 3 will develop the context of the study on wood mobilization in France. Section 4 is focused on our action research as well as our methodological proposal in Living Lab project mode. Then, section 5 will justify the choice of our study territory and will show the implementation of our methodology with associated methods. Section 6 will show the results and discuss them by putting them in perspective with the international scientific literature. Section 7 will explain the main limitations of our study and finally section 8 will conclude the paper and will give the main research perspectives.

## **2. Theoretical framework**

### **2.1 Innovation research: a growing discipline in the forest-based sector**

In recent years, innovation has become a distinct research field in forestry and timber industry (Weiss et al., 2020). Numerous studies have attempted to provide answers to policy-makers and practitioners to address the main issues and challenges at the heart of the forest-based sector (development of the bioeconomy, adaptation to and mitigation of climate change, forest renewal, citizens' expectations of forests, reconciling ecosystem services, etc.) (Lovric et al., 2020; Weiss et al., 2020). Indeed, researchers have applied approaches from innovation research such as social innovation (Moulaert et al., 2013), triple helix approaches (Etzkowitz and Leydesdorff, 2000), quadruple helix and quintuple helix approaches (Grundel and Dahlström, 2016), open innovation approaches (Henttonen and Lehtimäki, 2017; Schwerdtner et al., 2015) approaches that include institutional, governance or cultural aspects are the concepts of innovation ecosystems (Valkokari, 2015), user-centered approaches and value-based approaches (Vargo and Lusch, 2004; Toivonen and Kowalkowski, 2019). We note that some of these approaches have been applied to address the problem of wood mobilization in NIPF: among the most cited, Rametsteiner and Weiss (2006) defined the shift from an innovation process concept to system models. In addition, they identified a series of weaknesses in the current structure of innovation systems. Kubeczko et al. (2006) investigated the extent to which sectoral or other innovation systems support the innovation performance of forest operations. Von Willert and Krott (2019) used an IT-based approach to forest owner activation that applies bi-production research to forest policy and IT practices. Finally, Kilcline et al.

(2021) propose to develop a comprehensive innovation systems framework, integrating structural and functional streams of innovation systems research. This framework is called "structural-functional coupled" and is applied in a case study in Ireland to identify issues related to the potential for co-innovation and wood mobilization in the sector. Our study is in line with these researches by trying to bring scientific contributions to design innovative forest management and forest wood systems. Our originality is the implementation of practical projects in Living Lab mode, within the framework of an action research.

## **2.2 Living Lab approach**

### 2.2 Living Lab approach

#### 2.2.1 Definition and clarification of the concept

Associated with the two paradigms of Open innovation and User innovation, the Living Lab approach is characterized by a diversity of definitions. It is worth noting that many authors acknowledge W.J. Mitchell as the originator of Living Labs, but the lack of scientific literature has raised doubts about writing a single definition and a common theoretical framework (Berthou, 2018). Over the years, the numerous researches on Living Labs, analyzed in different contexts, have led to the emergence of numerous definitions. We propose to present the most cited in the literature (Appendix 1). Some authors indicate that these numerous definitions would lead to a lack of understanding of the Living Lab concept and its underlying mechanisms (Bergvall-Kåreborn and Ståhlbröst, 2009; Compagnucci et al., 2021, Lacroix, 2019). Although there are many definitions, convergences exist. We propose below to present these convergences or more precisely the different points of view of the authors who are assimilated to the definitions presented (it should be noted that the Living Lab is always defined by at least one of these points of view and sometimes even by several):

- A research methodology (Bergvall-Kåreborn and Ståhlbröst, 2009; Dell'Era and Landoni, 2014; Eriksson et al., 2005; Ponce de Leon, 2006) in which innovations, such as services, products, or application enhancements, are created and validated in empirical, multi-contextual, and collaborative real-world environments (Almirall et al., 2012; Ballon et al., 2005). It should be noted that the Living Lab covers a wide range of methodologies, which is why each project conducted in Living Lab mode adopts an approach that can develop its own methodology to serve a unique context (Dell'Era and Landoni, 2014)
- A user-driven open ecosystem: Being open innovation ecosystems, Living Labs enable knowledge and technology transfer between the different actors collaborating (Hossain et al., 2019). They form the "Living Lab network" which is based on the principle that all actors involved collaborate to create value and will benefit from it (Lehmann et al., 2015).
- An experimentation environment (Ballon et al., 2007; Bergvall-Kareborn et al., 2009; Bergvall-Kåreborn and Ståhlbröst, 2009; European Commission, 2009; ENoLL, 2016): Living Labs are seen as providing an environment to evaluate experiences and experiment with them in a real and familiar context of use for stakeholders and users (Schuurman et al., 2011).

- An innovation intermediary (Almirall and Wareham, 2011; Ståhlbröst and Bergvall-Kåreborn, 2008) between stakeholders and users. Living Labs serve as intermediaries between citizens, research organizations, businesses, cities, and regions for co-creation of shared value, rapid prototyping, or validation to increase innovation and business (Evans et al., 2017).
- A system (ENoLL, 2007). In this definition, the Living Lab is considered from a systems perspective that includes users as active co-creators, but the real-life environment is excluded. The systemic perspective includes the relationship between stakeholders and the application context.
- A Public-Private-Population Partnership (PPPP): In Living Labs, the stakeholders and users involved form Public-Private-Population Partnerships (PPPP) composed of companies, public agencies, universities, institutes and users. They all collaborate to create, prototype, validate, and test new technologies, services, products, and systems in real-world settings (Hossain et al., 2019; Leminen, 2015). The Living Lab approach is part of an opening of actors in "PPPP", which allows the approach to obtain maximum benefits: the private sphere is flexible and reactive in the project, the public sphere is guarantor of the legal and financial frameworks and the confrontation of ideas with the population sphere helps to adjust the product or service under development to the real needs of the users (European Commission, 2009).

Nevertheless, as Bergvall-Kareborn et al. (2009) and Skiba (2014) argue, Living Labs are a combination of all these definitions and views. In the remainder of this section, we propose to refine the understanding of the Living Lab concept with the identification and analysis of its characteristic determinants.

### 2.2.2 Key characteristics and determinants common of the Living Lab approach

As mentioned above, some authors share the observation that the numerous definitions of the Living Lab complicate the understanding of this concept. To overcome this difficulty of understanding, several studies have identified and analyzed the determinants that characterize the Living Lab concept. We propose a literature review to present these determinants, which can take different titles such as key characteristics, components, elements and key aspects.

- Key characteristics (Følstad, 2008; Hossain et al., 2019; Leminen, 2015; Voytenko et al., 2016) : Følstad (2008) identifies several key features: context (e.g., research context, real-world context, etc.), users (involved as co-creators), innovation activity (e.g., co-creation, evaluation, etc.), challenges, and innovative outcomes. Hossain et al. (2019) in their literature review, identify other key characteristics: real-world environments (the research context), stakeholders (along the lines of a Public-Private-Population Partnership), innovation activities (exploration, co-creation, experimentation, and evaluation), business models and networks, methods, tools, and approaches (multi-methods), challenges, outcomes, and sustainability of the process. Leminen (2015) identified four characteristics: real-world environments, stakeholders (based on a Public-Private-Population Partnership), methodologies, and methods and tools. Voytenko et al.'s (2016) study lists geographic context, experimentation, learning, participation, user involvement, ownership of the innovation, and evaluation.
- Components (Bergvall-Kåreborn et al., 2009): These authors identified several components in Living Labs: infrastructure, innovation management, partners and users, research, and approaches.

- Elements (Evans et al., 2017; Mulder et al., 2008; Veeckman et al., 2013): Evans et al. (2017) indicate that Living Labs share five common elements: Multi-method approaches, multi-stakeholder participation (based on a Public-Private-Population Partnership), user engagement, real-world setting, and co-creation. As for Mulder et al. (2008), they identified: User Engagement, Service Creation, Infrastructure, Governance Management, Innovative Outcomes, and Methods (and Tools). Finally, Veeckman et al. (2013) identified, first, constituent elements of the Living Lab environment, namely: a technical infrastructure, an ecosystem approach, a high level of openness, a community, a process lifespan, scales of applications, and a real world context. And second, constituent elements of the Living Lab approach: an innovation assessment, research context, co-creation, and the central role of the user.
- Key aspects (Leminen and Westerlund, 2016) : These authors emphasize systems (networks and ecosystems), environment (real-world environments) and approach, user and public participation, innovation activities as well as the innovation project.

It should be noted that the previously stated determinants are intrinsically linked to each other (Berthou, 2018). Even if we note some divergences between authors, we have mostly noticed convergences. Based on these convergences, we propose to present and detail the determinants common to the different studies cited above (we base this presentation on the study by Evans et al., 2017):

- Multi-stakeholder mobilization and participation according to public-private-population partnership (PPPP): Multi-stakeholder mobilization and participation according to public-private-population partnership (PPPP) is of crucial importance. This involves mobilizing all the actors in the quadruple helix: representatives from the public and private sectors, academia, and the public. Furthermore, in a Living Lab, stakeholders are organized according to specific roles. Nyström et al. (2014) identify 17 roles in a Living Lab: initiator, instigator, promoter, advocate, producer, planner, prop provider, coordinator, builder, messenger, facilitator, orchestrator, integrator, informant, tester, contributor, and co-creator.
- User involvement and the centrality of end-users: In a Living Lab, users are considered co-producers in the development of new products and services as well as new uses of devices and infrastructure (Pascu and Van Lieshout, 2009). One of the keys to the success of Living Labs is to involve users from the beginning and throughout the innovation process (Evans et al., 2017).
- Co-creation: According to Dubé et al. (2014), co-creation refers to the set of collaborative value-creation processes involving the stakeholders involved from the conception to the use of a product or service. Co-creation includes all collaborative activities within the process. It strongly characterizes the Living Lab approach, which aims to achieve mutually designed and valued outcomes that are the result of the active engagement of all stakeholders and users in the innovation process (Evans et al., 2017). Co-creation shares a common value with the Living Lab, as both aim to engage participants in collaboration (DeFillippi & Roser, 2014; Lee et al., 2012). Indeed, it engages stakeholders and users in collaboration to develop collective skills to design solutions (DeFillippi and Roser, 2014). It should be noted that co-creation includes five domains: co-ideation, co-assessment, co-design, co-testing, and co-launching (Russo-Spena and Mele, 2012).

- A multi-method approach that mobilizes many tools: Living Labs combine and adapt different user-centered co-creation methods to best meet their purpose (Evans et al., 2017). Authors indicate that Living Labs pilot, develop and experiment with different methods based on the results of innovation activities (Leminen and Westerlund, 2012). Mulder (2012) on the other hand states that Living Labs use methods and tools in a heterogeneous way. In this regard, Leminen and Westerlund (2017) identify standardized (generic) and customized (highly customized) tools. Dubé et al (2014) show the diversity of methods and tools that Living Labs mobilize in the phases of the innovation process.
- A real-world context: Living Labs are real-world environments in which it is possible to experiment, develop, co-create, validate, and test existing products, services, and systems (Leminen et al., 2012). It is a physical or virtual space, where the collaborative aspect is central (Lenne, 2015) and whose implementation responds to research needs and industrial or societal problem solving by bringing together various stakeholders for collective and collaborative practices (Lacroix, 2019). The real-world anchoring of Living Labs in realistic environments allows for greater scientific and societal impact than other innovation approaches (Pallot et al., 2010).

### 2.2.2 Project management methodologies in Living Lab mode

Dell'Era et al. (2014) define a Living Lab methodology as "a research methodology aimed at co-creating innovation through user participation in a real-world context." It is worth remembering that innovation steering that mobilizes a Living Lab methodology aims to produce innovation outcomes (Boly et al., 2016; Priday et al., 2018) while orchestrating the relationships between different stakeholders and users according to a Public-Private-Population Partnership (Almirall and Wareham, 2011). Living Lab methodologies allow the deployment of an innovation space and process, in project mode, adjusted according to the dynamics produced by the context and the mobilized actors (Skiba, 2014; Ståhlbröst and Holst, 2017). Indeed, the implementation of Living Lab methodologies to drive innovation has given rise to models of innovation processes in Living Lab project mode. The term "project mode", which was notably initiated by Skiba (2014) is used because it refers to the management of innovation by project. Thus, we can indicate that Living Lab methodologies allow generating an innovation process in Living Lab project mode, as they follow the determinants characteristic of the Living Lab approach in an innovation process. We propose below a literature review of the existing methodologies to drive innovation processes in Living Lab project mode. More specifically, we will present the phases of the innovation process, their implementation steps as well as the associated animation and management methods and tools.

**Table 1:** Methodologies (and their phases) of project management in Living Lab mode.

| <b>Publication</b>        | <b>Phases</b>   | <b>Application context</b>  |
|---------------------------|---|---|
| Pierson and Lievens, 2005 | <ol style="list-style-type: none"> <li>1. Contextualization</li> <li>2. Concretization</li> <li>3. Implementation</li> <li>4. Evaluation</li> </ol> | Project related to the study of communication to examine user involvement in the design of Information and Communication Technologies (ICT) |



|                                      |   |  |
|--------------------------------------|---|--|
| Schaffers et al., 2009               | <ol style="list-style-type: none"> <li>1. Diagnosing</li> <li>2. Action Planning</li> <li>3. Action Taking</li> <li>4. Evaluation</li> <li>5. Learning</li> </ol>   | Development of rural areas   |
| Pallot, 2009; Pallot and Pawar, 2012 | <ol style="list-style-type: none"> <li>1. Exploration of ideas within multidisciplinary workshops</li> <li>2. Co-creation of specific ideas and elaboration of solutions</li> <li>3. Experimentation of the solutions in real life environment</li> <li>4. Evaluation of results and methodology</li> </ol>   | Projects in three different usage areas related to services based on the Internet of Things (IoT), wellness and the environment. |
| Ståhlbröst and Holst, 2012           | <ol style="list-style-type: none"> <li>1. Planning</li> <li>2. Design</li> <li>3. Prototyping</li> <li>4. Development</li> <li>5. Deployment</li> </ol> <p>And the four innovation activities, for each steps, in an iterative cycle: exploration, co-creation, experimentation and evaluation</p>  | Energy project   |
| Tang and Hämäläinen, 2012            | <ol style="list-style-type: none"> <li>1. Visualization</li> <li>2. Prototyping</li> <li>3. Evaluation</li> <li>4. Dissemination</li> <li>5. Adoption</li> </ol>  | Technology services  |
| Dupont et al., 2014                  | <ol style="list-style-type: none"> <li>1. Diagnosis of usages (Reading the territory, Crossing knowledge, Identifying expectations and needs)</li> <li>2. Integration of usages' expectations in urban project design (Focusing and Deepening, Ranking, Making functional scenarios)</li> <li>3. Consolidation of designed solutions with users (testing, Making strong, Adjusting the implementation)</li> </ol> | Urban project: designing an eco-neighborhood   |
| Coenen et al., 2015                  | <ol style="list-style-type: none"> <li>1. formulate the problem</li> <li>2. build and evaluate</li> <li>3. formalize and learn</li> </ol>   | ZWERM project: Creation of social environment in cities and knowledge creation (Laureyssens et al., 2014)                        |
| Evans et al., 2017                   | <ol style="list-style-type: none"> <li>1. Exploration</li> <li>2. Experimentation</li> <li>3. Evaluation</li> </ol>   | Four case studies in the domains of health, home care, agrifood and urban development  |
| Steen and Bueren, 2017               | <ol style="list-style-type: none"> <li>1. Research</li> <li>2. Development</li> <li>3. Testing</li> </ol>   | Organization of sustainable urban interventions  |

|                      |   |   |
|----------------------|---|---|
|                      | <ol style="list-style-type: none"> <li>4. Implementation</li> <li>5. Commercialization</li> </ol>   |   |
| Mastelic, 2019       | <ol style="list-style-type: none"> <li>1. Identification of key stakeholders</li> <li>2. Pre-analysis of key stakeholders.</li> <li>3. Semi-structured qualitative interviews</li> <li>4. Stakeholder workshop.</li> </ol>                      | Improve building energy management systems                    |
| Cerreta et al., 2020 | <ol style="list-style-type: none"> <li>1. Co-exploration</li> <li>2. Co-design</li> <li>3. Co-evaluation</li> </ol>   | Reactivate the tourist visits of cultural properties in Italy |
| Lupp et al., 2021    | <ol style="list-style-type: none"> <li>1. Understand, investigate, plan, explore</li> <li>2. Creative co-design and refinement aimed at co-creating solutions</li> <li>3. Evaluation dedicated to "evaluating the designed solution"</li> </ol> | Co-design Nature Based Solutions                              |

### 2.2.3 The Living Lab approach applied to the forest-wood sector

In the literature, the Living Lab approach has been very rarely used in the forest-wood sector. Only some projects and papers refer to an application in the forest-wood sector. The LiveRUR project (2018- 2021) focuses on Living Labs as innovative business models and their adaptation to rural areas in Europe (Kallai, 2018). It is based on the principles of sustainable development of resources and local economies and seeks to improve the diversification of local economies. It identifies forestry as one of its main fields of activity, but does not provide further explanation. The InnoReNew Living Lab operates within the InnoRenew CoE (InnoRenew Centre of Excellence for Research and Innovation on Renewable Materials and Healthy Environments), an independent research institute founded in 2017 by the Fraunhofer WKI (Turk Mehes, 2019). As part of its activities, the Living Lab InnoRenew plays an active role in its community in the development of wood and bio-sourced products, for example by organizing events to explore wood and its properties at the local elementary school, encouraging students to take an interest in wood as a material and in science in general. Beyond these examples of projects that refer to Living Labs, we note to date two comprehensive studies on the application of Living Labs in the forestry-wood sector. First, Ponsard and Nihoul (2020) have developed a Living Lab to improve sustainable forest management in Luxembourg. Activities aim at bringing together people from different backgrounds and identifying mutually enriching use scenarios. Secondly, Lupp et al. (2021) have applied the Living Lab approach to co-design nature-based solutions (NBS) in the context of both the restoration of the Isar-Plan River in Munich, Germany, and the “Mountain Forest initiative” (which is a project 2009-2014 launched by the Bavarian Ministry of Food, Agriculture and Forestry to restore the protective function of the vulnerable alpine forest in light of climate change).

### 3. Study context

In France, the 2014 Law of the Future for Agriculture, Food and Forestry (LAAAF) and the National Forest and Wood Program (PFNB) 2016-2026 announced the orientations and objectives of forestry policy for a ten-year period. Just before, to prepare these directions and objectives, five ministries in France (respectively in charge of agriculture and forestry, research, industry, ecology and energy, rural area development) have commissioned a report from several

institutions in order to strengthen research, development and innovation through a “Research and Innovation Plan 2025” for the forest wood sector (D’Amécourt et al., 2016). One of the axes of this Plan, to which our study is included, indicates that the wood industry expresses a strong need for innovation to meet the additional demand for biomass to support economic and ecological transitions. To meet this demand, like the European situation explained in the introduction, the French forestry sector has been striving for many years to involve NIPF owners in sustainable forest management approaches aimed at mobilizing wood (Alexandre, 2017, Elyakime et al., 2015). In France, forests represent 33% of the national territory with 25% public forests and 75% private forests (IGN, 2018), shared by 3.5 million owners of which about 3 million own less than 25 hectares and only a small portion have a sustainable forest management document (CNPFF, 2015). According to Colin and Thivolle-Cazat (2016), it is precisely in these private forests of less than 25 hectares that do not have a sustainable management document where the additional wood resource must be mobilized<sup>1</sup> as the possibility of large public and private forests is saturated.

However, many difficulties prevent the mobilization of wood in these ownerships, for example, the low economic value of these forests (Ademe, 2011), the lack of interest of owners in forest management (Alexandre, 2017), the discouragement of owners due to health attacks (François and Vallance, 2019), the general lack of trust between industry and society (Moffat et al. 2016) enhanced in French mass medias. In France, since the 2000s, forest policies have attempted to involve NIPF owners in forest management processes with the objective of mobilizing wood. As a result, many policy instruments have been put in place (see appendix 2 for the main policy instruments). These policy instruments are mainly implemented by two state organizations: The “Centre National de la Propriété Forestière” (CNPFF) and the forest service of the “Chambre d’Agriculture”. These two organizations are supposed to provide advices to forest owners, and they work to get in touch with NIPF, through territorial projects joining several partners. Beside these public organizations are forestry cooperatives, whose objective is to bring together forest owners to pool their resources in order to create more coordinated management units for wood harvesting. They try to federate new forest owners and are able multiply and maintain grouping actions motivated by the economic objective of selling wood (François and Vallance, 2019). It should be noted that these policy instruments, the actions of the CNPFF and the Chambers of Agriculture, and the cooperative model have succeeded in involving a significant number of NIPF owners in mobilizing wood (Ademe, 2011; Sergent, 2017). But one of the main conclusions of the current literature is that there are still many NIPF owners who do not manage their forests or do so without adhering to sustainable management principles (Elyakime et al., 2015; Poss, 2017).

In France, there are also weaknesses that explain this situation, but the literature highlights the same two main weaknesses as at the European level:

- Not all of these policy instruments are designed to meet the needs and expectations of different types of NIPF. As a result, many policy instruments are not used or are misused by NIPF (Elyakime, 2015).
- There is a lack of collaboration among stakeholders to co-construct and deploy these policy instruments and measures (François and Vallance, 2019). As a result, stakeholders do not always pool their skills and knowledge to address this issue and therefore do not participate in their deployment (Sergent, 2014).

Because of this situation, policymakers and practitioners are calling for the implementation of innovative approaches to provide answers to this difficult situation that has persisted for many years (Alexandre, 2017; François and Vallance, 2019). That’s why the Wood Sector Research

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<sup>1</sup> In France, all properties larger than 25 hectares must have a Simple Management Plan (Sustainable Management Document) and are therefore theoretically managed (Colin and Thivolle-Cazat, 2016).

and Innovation Plan 2025 has proposed to promote and accelerate collective innovation through the creation of territorial Living Labs reconciling forest production, bioeconomy and ecosystem services (Action A.3-2, page 115 in D'Amécourt et al., 2016). Our study is therefore in line with this approach, proposing an innovative project management methodology in Living Lab mode, based on an action research approach, to involve more NFIP owners in sustainable forest management approaches aimed at mobilizing wood.

## **4. Research method**

### **4.1 Proposal of a methodological reference framework for piloting forestry Living Labs**

Our generic methodological framework for the management of forest Living Labs is composed of a theoretical framework of action that is divided into two parts: 1) The phases of the methodology and, 2) The management method by steps for each phase. And on the other hand, a research approach based on an action research posture. We present these different parts below.

#### **4.1.1 A theoretical framework for action**

##### **1) The phases of the methodology**

Evans et al. (2017) indicate that methodologies are most effective if they are tailored to the nature of a project, an application context, stakeholders and users, and the expected outcomes of the innovation. Following the presentation of our theoretical framework, we have a clearer vision of the phases and stages of implementation mobilized by the Living Lab methodologies, which make up an innovation process in Living Lab project mode. We will therefore present the methodology that we will use for the rest of our work.

In most of the methodologies presented above, a preparation phase called "planning" is proposed. This phase is highly recommended by authors such as Dubé et al. (2014) and Ståhlbröst and Holst (2012), as it aims to bring out the problematic (and research questions), the objectives (and ambitions) and the questioning of the actual context. Furthermore, it aims to organize the timelines and plan the Living Lab process. Finally, this phase also includes the mobilization of stakeholders and users in the innovation process.

Then, an "exploration" phase very often follows this first phase. The objective is to question the "opportunity", to place it in its context of use or practice by highlighting the issues that will lead to the formulation of a problem (Lacroix, 2019). This phase reports on the current state of use (Brown, 2008). Stakeholders and users ask about the "current state" and how to design "possible future states" (Evans et al., 2017). Within this phase, the authors propose to carry out a shared diagnosis (or shared vision) to collectively formalize the problematic, the stakes and the questionings related to the project (Dupont et al., 2014). In addition, an exploration of uses is carried out with a focus on the end-users allowing them to identify and characterize their needs to facilitate the design of solutions.

The third phase that stands out seems to concern the collective design of solutions. We will call this phase "creative co-design of solutions". First, the goal is to collectively obtain an idea of the future solution (Steen and Bueren, 2017). Second, ideas for new concepts should be co-created in collective creativity sessions involving all relevant stakeholders and users. The co-creation of solutions is refined through iteration until a prioritization of those identified as the most innovative and generating maximum positive impact.

The fourth phase, "experimentation and implementation of solutions", consists of a confrontation of the co-created and validated solutions, in relation to the initial problem, with and by stakeholders and users in the real environment (Steen and Bueren, 2017).

Experimentation and implementation of solutions are conducted with users in the real environment to iteratively adjust the final form of the product or service under development (Brown, 2008). Testing and implementation are conducted on a small scale with willing and motivated users.

Next, Nesterova and Quak (2016) identify two levels of evaluation: evaluation of the Living Lab process and evaluation of the innovation solutions designed as a result of the process. In both cases, the objective is to evaluate the added value created since the planning and exploration phases (diagnosis of the current state) by the innovation. From this analysis, the methodology first goes through a phase of "solution evaluation" which translates into the assessment of concepts, products and services according to ergonomic, socio-cognitive and socio-economic criteria (Pallot, 2009). In other words, it is a matter of evaluating the impact of the solution compared to the current state. If the evaluation phase of the solution is negative, the authors advise restarting the iterative process to improve it since the exploration phase. On the other hand, if the evaluation is positive, the process moves on to the next phase of "deployment" (which can also be called dissemination or commercialization), which aims to implement the tested solutions on a larger scale than the experimentation and implementation phase. The authors also discuss the notion of using the innovation result in the real environment. Once the process is completed, the second part of the evaluation related to the innovation process is carried out. It consists in evaluating the impact of the Living Lab compared to the initial situation in the real environment. The last phase is a replication of the innovation process and solutions. This phase, which we will call "replication and adaptation of the solutions and methodology", allows the dissemination of the research work in other environments in order to test its robustness and genericity. We recall here that our methodological frame of reference is intended to be generic and adaptable to the response of all forestry issues (not only the bioeconomy).

Finally, it should be noted that the current societal context, characterized by uncertainty and complexity due to the uncontrollable dynamics of everyday life, has favored the emergence of iterative process models of the Living Lab. They allow for a better ability to adapt and anticipate situations (Bergvall-Kåreborn et al., 2009; Lacroix, 2019; Ståhlbröst, 2008; Ståhlbröst and Holst, 2012; Steen Van Bueren, 2017), and the interaction between phases promotes anticipation and adaptation for innovation development (Leminen et al., 2015). Thus, our phases will be deployed in an iterative process.

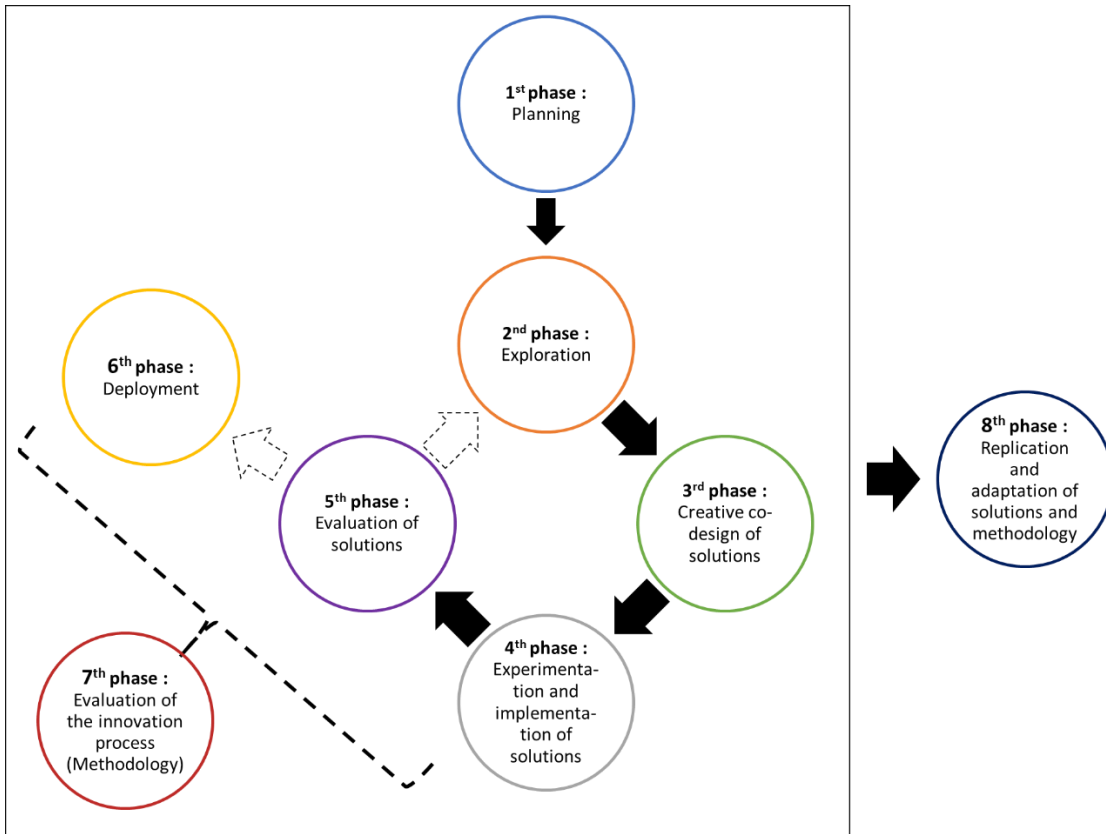


Figure 1: A theoretical framework for action: The phases of the methodology

2) The way each phase is conducted in phases

Our literature review indicated that the phases of the methodologies are accompanied by implementation steps to pilot the Living Lab. Based on the scientific literature, we propose below as an example our proposal for the planning and exploration phases (Figure 2 and 3). This principle is applied and adapted to each phase.

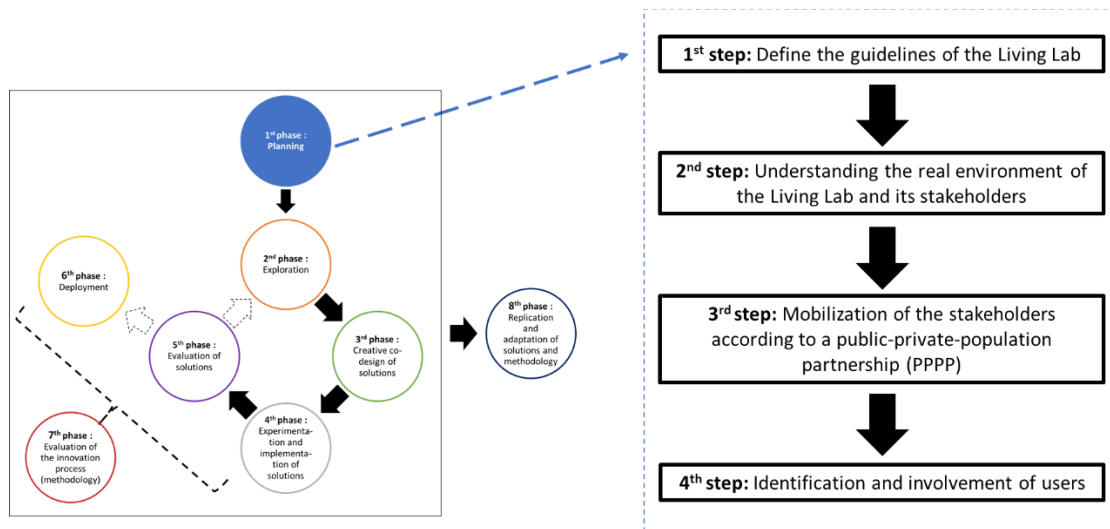


Figure 2: Steering mode of the planning phase

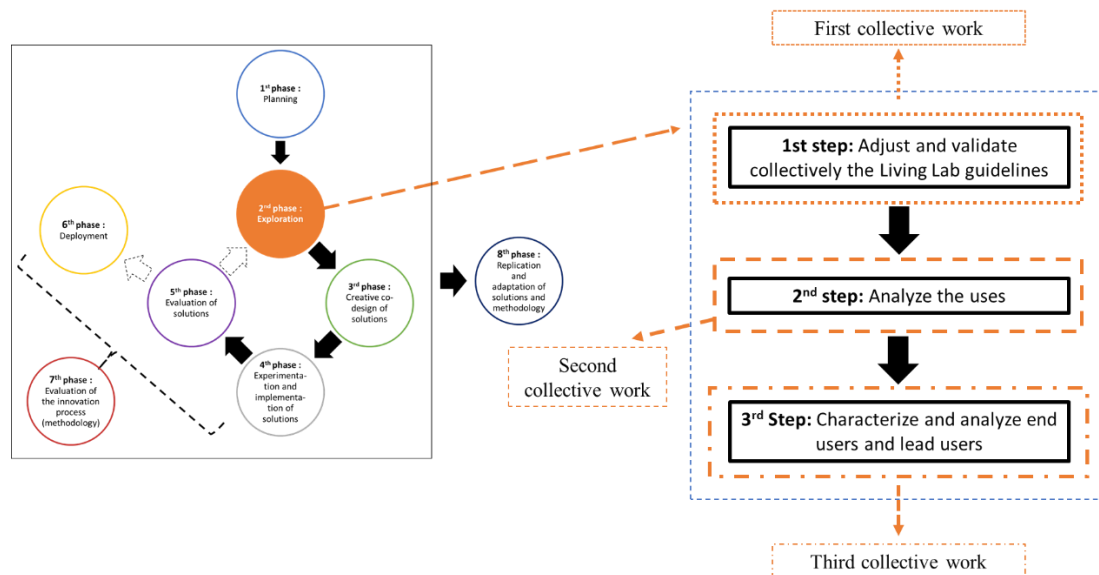


Figure 3: Steering mode of the exploration phase

#### **4.2 The approach: An action research**

Action research is a form of research whose objective is to find a solution to an operational problem while disseminating theoretical knowledge to the research community at large (Chiasson et al., 2009). It focuses on both theory and practice, so it is important for the researcher to consider these two parallel and interacting cycles: the research cycle (focused on scientific objectives) and the practice cycle confronted with a real situation (focused on an operational problem) (Chiasson et al., 2009). The literature seems to agree that action research that has already been experimented with in Living Labs (Ståhlbröst, 2008; Schaffers et al., 2009) is a recommended and appropriate posture for research in Living Labs (Logghe et al., 2017; Ståhlbröst, 2008). It is worth noting that it is used as a method to build methodologies from concrete cases and projects carried out in Living Labs (Dell'Era and Landoni, 2014). This is why we are going to experiment the relevance of our methodological framework for the management of forest Living Labs according to an action research that will allow us to occupy two positions. We can indicate here that the role of researchers has evolved in the theoretical approach of the Living Lab. Indeed, in the context of a public-private-population partnership, researchers constitute a differentiated category, which can bring skills in setting up, piloting and leading Living Labs (Schuurman et al., 2014).

Thus, the first position occupied is that of the "immersed researcher" in his ecosystem. The researcher pilots his Living Lab by occupying the roles of animator ("Orchestrator") and facilitator (Nyström et al., 2014). The animator (orchestrator) is an actor who organizes and manages all members of the Living Lab's network of actors.

This actor guides and supports the activities within the network while the facilitator helps the actors to achieve a desired goal or find an appropriate direction. The roles of the "orchestrator" facilitator and the facilitator are still similar, but while the facilitator supports a specific group, such as users, in the innovation process, the facilitator (orchestrator) is responsible for driving the entire network towards the expected goals (Nyström et al., 2014). These roles help drive the innovation process by adapting the methodology to the real environment (Ståhlbröst, 2008), as it is the researchers who are responsible for the methodological choices in Living Labs (Schuurman, 2015).

The second is that of the "researcher observing" the project and its ecosystem to answer the research question (Ståhlbröst, 2008). The researcher collects and processes data using different qualitative and quantitative methods and formalizes the results throughout the project to address

the scientific and operational objectives (Figure 4). Formalization is often achieved through the creation of intermediate design objects (boundary objects) that support the management of the innovation process (Blanco and Boujut, 2003; Vinck, 2011). Boundary objects are generally mobilized to ensure the formalization, capitalization and restitution of innovation results (Steen and Bueren, 2017). Their nature is multiple and adapts to the phases of the innovation process (Paskaleva et al., 2015) and especially to the actual environment of the Living Lab. Moreover, they allow capitalizing and structuring the knowledge produced throughout the innovation process by formalizing an analysis of the previous stage and a starting point for the next one (Lacroix, 2019).

Finally, the action research framework is adapted to our research work, as it allows the researcher to enter a real situation, to participate in the reflections in this situation according to a specific role, and then to leave the situation to answer the research questions previously asked (Dupont, 2009). Finally, by following a form of action research, the interest is that the research is not separated from the theoretical construction and the operational construction, because a mutual dynamic is implemented.

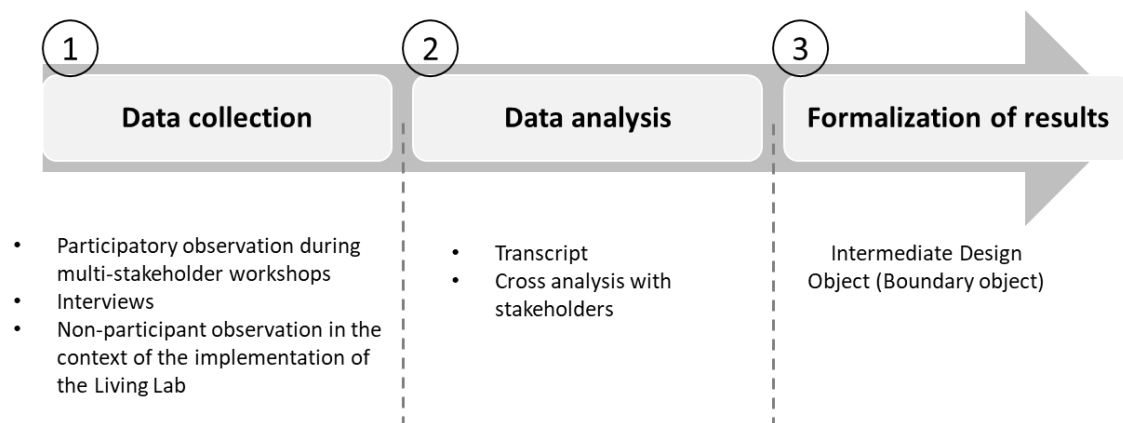


Figure 4: Our action research approach

## **5. Implementation, data collection and analysis**

### **5.1 Study area**

As indicated in the introduction, we propose to implement our methodology in the Vosges department (eastern France). It is composed of diverse forests (deciduous and coniferous, mountains and plains, plantations and semi-natural, public and private forests). Indeed, this department is covered by about 290000 hectares of forest and 48% of wooded areas, making it the third most wooded department in France (IGN, 2018). This forest (surface area) is composed of 55 % deciduous trees (mainly sessile and pedunculate oaks and common beeches) and 45 % conifers (common spruce and pectinated firs) (IGN, 2013). The annual harvest in this department is about 1.2 million m<sup>3</sup>: 640,000 m<sup>3</sup> of softwood, 160,000 m<sup>3</sup> of hardwood and 400,000 m<sup>3</sup> of industrial and energy wood (Agreste, 2015). The Vosges department seems to be a favorable territory for the development of our Living Lab methodology for several reasons:

- In the Vosges, there are clear local policies in favor of the development of the forest bioeconomy which are fully in line with the national objectives of mobilizing wood to accompany economic and ecological transitions (DRAAF Grand-Est and Fibois, 2019).
- A wide range of local forestry stakeholders (public and private forest managers, wood industries, hunters, local agencies of public institutions, etc.) are working to develop the



bioeconomy in this area (DRAAF Grand-Est et Fibois, 2019). This wide range of actors can allow us to facilitate the co-creation phases in our Living Lab approach by bringing together more easily the three spheres of public, private and population.

- This area seems to represent well the situation of European NIPF with a diversity of forests, owners and also a strong fragmentation of private forest which represents about 113 000 hectares (IGN, 2013) for 48623 owners, of which about 44 000 own less than 4 hectares and 34 000 less than 1 hectare (CRPF, 2006). In the perspective of our seventh step of our methodology concerning the replication and adaptation of our innovative solutions and methodology, this territory could allow us to have a first quite robust and generic prototype.
- Although both forest industry and forest tourism are strongly developed, the social movement against timber harvesting is not dominant. Valuable wood uses as innovative building, luxury furniture or violin making made the reputation of the territory (INSEE, 2012; Serre and Kibamba, 2015).

## **5.2 Implementation of our methodological reference framework for the management of forestry Living Labs**

In this study, we have implemented the phases of planning, exploration and creative co-design of solutions of our methodological framework for the management of forestry Living Labs. Here we adapted our methodological framework to answer our research question concerning the improvement of the integration of non-industrial private forest owners in forest policy and bioeconomy issues. We present in this section the phases implemented so far and their associated steering steps.

### 5.2.1 1<sup>st</sup> phase - Planification phase

#### *1<sup>st</sup> step: Define the guidelines of the Living Lab*

From the beginning of the Living Lab, it is advisable to define the problematic (and the research questions), the objectives (and ambitions), the deadlines and the necessary means (technical, human, etc.) adapted to the real environment in which the Living Lab is going to take place. The researcher carries out this step alone at first and will validate it collectively with the participants of the Living Lab at a later stage. For this first step, we relied on Lupp et al. (2018) to establish a panel of questions that allows us to prefix the Living Lab guidelines before an exchange with participants.

#### *2<sup>nd</sup> step: Impregnation and understanding of the real environment of the Living Lab and its stakeholders*

The impregnation and the understanding of the real environment of the Living Lab and its stakeholders is necessary because this step allows to know the specificities of the real environments at the political, economic, social level, etc., to identify the projects in progress to which the Living Lab could be articulated and to understand the interests of the stakeholders (their conflicts, their collaborations, etc.). We carried out documentary work to understand our real environment and its stakeholders. In addition, ten semi-structured interviews based on an interview guide and five days of participant and non-participant observation were conducted. The participant and non-participant observation were based on the same data as for the semi-structured interviews, i.e., the observation had to answer the questions in the guide. Thus, we sought to understand which actors were present on the territory, their logic of actions and

missions and their interests in relation to the targeted problem. To formalize this data, we propose to rely on Lupp et al.'s (2018) matrix model for identifying and describing actors, which is presented in the form of the private-public-population partnership.

### 3<sup>rd</sup> step: Stakeholder mobilization through a public-private-population partnership (PPPP)

For this third step, authors seem to agree that the model of Paskaleva et al. (2015) is the most successful methodological approach for stakeholder mobilization in a Living Lab (Lacroix, 2019; Schuurman, 2015). We therefore propose to adapt the steps of this model as follows:

- The first step of "stakeholder mobilization" consists of identifying the stakeholders to be involved in the Living Lab. Our interviews as well as our previously conducted observation allow us to obtain an identification of the stakeholders.
- The second step is "stakeholder enrolment" which consists in identifying what could motivate them to contribute. Many studies indicate that both intrinsic and extrinsic motivations can be drivers of engagement (Ståhlbröst and Bergvall-Kåreborn, 2011). We propose to communicate with stakeholders individually while tailoring the discourse to each stakeholder.
- The third step is the "stakeholder dialogue" which consists of engaging stakeholders in the Living Lab innovation process. We propose to contact the stakeholders by putting forward arguments to motivate them. Specifically, we propose to convey a message that emphasizes the individual benefits that stakeholders can obtain by joining the Living Lab. We propose to explain how the innovation process will address their interests while contributing to collective interests.
- The fourth step is the constitution of a network of stakeholders who are sustainably involved in the innovation project. For this step, we will take into account the characteristics, identified by several authors, that summarize how to obtain a "good" functioning of the stakeholder network. Thus, our network will be composed of several diverse stakeholders taking into account the sharing of a common interest, its representativeness, its heterogeneity (age, gender, culture, ambitions); its capacity and decision-making power (Reed, 2008; Reed et al., 2009; Dvarioniene, 2015; Van der Jagt et al., 2017). In addition, we propose to engage stakeholders in a public-private-population partnership that respects the quadruple helix by having at least one representative from each agency, institution, or business identified in our real-world environment. Our main objective is to have the representative from the organization or institution most likely to address the targeted problem. This network of actors must be permanently involved in the innovation project according to a quadruple helix PPPP. This network is not fixed and must be inclusive enough to be able to integrate "new actors" that would be identified during the process (Doyon et al., 2015).

### 4<sup>th</sup> step: Identification and involvement of users

To identify users, we propose to rely on Skiba's (2014) classification: end-user, intermediate user, potential user and "Lead-User". Users will be identified based on the problematic emanating from the real environment of the Living Lab. The purpose of this identification and involvement is to design with them in order to better understand them and assess whether the product or service being developed has a chance to fit into their uses (Mallein 2010). In order to work with users, designers have developed a variety of strategies to integrate user uses into the design process, such as:

- Expanding the boundaries of the usage system under consideration;
- Integrating users from the early stages of the design process;
- Deepening the level of user knowledge achieved;

- Increasing the power of users to influence the development process.

### 5.2.2 2<sup>nd</sup> phase - Exploration phase

In the exploration phase, it is important to build and formalize a collective diagnosis and a shared vision of the Living Lab project, right from the beginning of the innovation process. A shared vision is considered to be the result of a joint effort of all actors and users to form an integrated vision of the goals and ambitions of the innovation for a successful Living Lab (Steen and Bueren, 2017). It is important to carry out this phase collectively with all stakeholders and users (PPPP).

#### 1<sup>st</sup> step: Adjust and validate collectively the orientations of the Living Lab and formalize a shared vision of the real environment

Following the mobilization and involvement of the stakeholders and users, we propose to start the first collective work which aims at adjusting and validating collectively the guidelines of the Living Lab, i.e. the problematic (and the research questions), the objectives (and the ambitions), the deadlines and the necessary means (technical, human, etc.) which were proposed by the researcher in the first step of the planning phase. This step is necessary because it aligns all participants in the Living Lab on the same basis before starting the co-design of solutions. The interests of all participants must be incorporated into these guidelines to ensure the start-up and sustainability of the Living Lab. Moreover, this first collective work allows to complete the previous steps of impregnation of the real environment and its actors and also to check if the researcher has not forgotten to mobilize the actors. In preparation for the workshop, the identified actors were contacted to participate in the workshop. Below we present the stakeholders present at the workshop (Table 2). The actors were selected according to the stakeholder analysis of the planning phase and mobilized according to the model of Paskaleva et al, (2015) while respecting the PPPP. On the day of the workshop, we proposed a facilitation method to both cross-reference the actors' knowledge and then modify and validate the Living Lab guidelines. The main results of this step besides the validation of the Living Lab guidelines are also the beginning of the constitution of the shared diagnosis which consists of a formalization of a collective understanding of wood mobilization in the small private forests of the territory as well as the co-construction of a shared vision on the difficulties to involve private owners in wood mobilization. Finally, at the end of the workshop, the data were processed and the results formalized according to a limited purpose that will be presented in the results section.

**Table 2:**

Stakeholders mobilized in the first workshop for the exploration phase

| <b>PPPP stakeholder category</b> | <b>Stakeholders</b>                | <b>Number of participants</b> |
|----------------------------------|------------------------------------|-------------------------------|
| <b>Public sphere</b>             | National Center of Forest Property | 1                             |
|                                  | Chambers of Agriculture            | 1                             |
|                                  | State public institution           | 1                             |
|                                  | National Forestry Office           | 1                             |
|                                  | Local authorities                  | 2                             |
|                                  | Academic research                  | 1                             |

|                   |                                |           |
|-------------------|--------------------------------|-----------|
|                   | <b>Subtotal</b>                | <b>7</b>  |
| Private sphere    | Private forest manager         | 1         |
|                   | Contractor                     | 1         |
|                   | Private owner's representative | 1         |
|                   | <b>Subtotal</b>                | <b>3</b>  |
| Population sphere | Environmental NGO              | 1         |
|                   | Local elected official         | 1         |
|                   | <b>Subtotal</b>                | <b>2</b>  |
|                   | <b>Total</b>                   | <b>12</b> |

### 2<sup>nd</sup> step: Analyze the uses

In this step, we seek to identify and analyze uses in order to integrate them as early as possible in the design process. Exploring and analyzing uses is necessary to begin collaborative work (Skiba, 2014). Three main elements can be explored and identified (Dubé et al., 2014):

- The meaning of use: "the meaning that the user brings to the use of the product or service".
- The situations of use: "the places or moments where use occurs in a preferential and natural way".
- The context of use: "the appropriation of the product or service within a particular community of users".

Exploring and analyzing usage theoretically promotes the development of innovations, as it takes into account the potential for acceptance and appropriation of the product or service (and its integration into usage) (Skiba, 2014). In our case, this step aims to obtain an overview of the multiple uses of the real environment of the Living Lab and allows us to develop hypotheses on the integration of the future product or service with the current uses of the users.

It should be noted that this second step was conducted in conjunction with the first one "Adjust and validate collectively the Living Lab guidelines and formalize a shared vision of the real environment" in order to optimize the participation of the stakeholders. Indeed, during the first workshop described above, we also analyzed and formalized the existing uses concerning wood mobilization in the NIPF.

### 3<sup>rd</sup> step: Characterize and analyze the end-users and lead-users and their needs and expectations.

End-users and core users are essential participants in the living lab, as they enable the emergence of "real needs" that will be used to generate innovation. End-users are considered as "experts in use". They must be involved in all phases of the process. They become co-creators, sharing their discoveries, impressions and experiences with the professionals (designers, developers, engineers, managers, etc.). Thus, this step allows to focus the innovation process on the elements of the real context that will serve as a basis for the creative co-design of solutions. This characterization and analysis of end-users and lead-users was carried out through two multi-actor workshops and six individual interviews. The personas method was chosen and adapted to our forestry context. This work was the subject of a previously published article (Arnould et al., 2021) that presents the method, the actors involved, the implementation

and the results of this step. The table 3 lists only the actors who participated in the multi-stakeholder workshops and interviews for this step.

**Table 3:**

Stakeholders who participated in the co-design of the forest owner personas (Arnould et al., 2021)

| PPPP stakeholder category | Stakeholders                       | Number of participants |
|---------------------------|------------------------------------|------------------------|
| Public sphere             | National Center of Forest Property | 1                      |
|                           | Chambers of Agriculture            | 1                      |
|                           | State public institution           | 1                      |
|                           | National Forestry Office           | 1                      |
|                           | Local community                    | 1                      |
|                           | Federation of Forest Communities   | 1                      |
|                           | Academic research                  | 1                      |
|                           | <b>Subtotal</b>                    | <b>7</b>               |
| Private sphere            | Private Forest Manager             | 1                      |
|                           | Contractor                         | 1                      |
|                           | Industrial                         | 1                      |
|                           | Representatives of private owners  | 2                      |
|                           | <b>Subtotal</b>                    | <b>5</b>               |
| Population sphere         | Environmental NGO                  | 1                      |
|                           | Hunting Society                    | 1                      |
|                           | Local elected official             | 1                      |
|                           | <b>Subtotal</b>                    | <b>3</b>               |
| <b>Total</b>              |                                    | <b>15</b>              |

### 5.2.3 3<sup>rd</sup> phase - Creative co-design of solutions

#### *1<sup>st</sup> step: Emergence and prioritization of solution ideas*

Innovation works on the basis of a divergence/convergence cycle that repeats until the concept of the new has been found and fixed (Skiba, 2014). Divergent thinking is the ability to expand the field of possibilities by proposing new, different, unique viewpoints and solutions in relation to a problem. Convergent thinking considers the ability to find the most suitable solution to the given problem. The divergence/convergence cycle therefore consists of generating as many ideas as possible, feasible or not, and then evaluating the relevance of these ideas in order to select the best one and implement it (Skiba, 2014). We will use this cycle to perform the emergence and prioritization of solution ideas.

In this step, we begin with divergence. This idea emergence will be performed based on previously identified user needs. A collective work with the actors and mobilized users will be done to generate a maximum of ideas that meet the identified needs (Ståhlbröst and Holst, 2012). To conclude this work, a collective prioritization, based this time on convergence, of the most adapted ideas to answer the problematic of the Living Lab and the needs of the users will be realized. We therefore propose a workshop for the emergence and prioritization of solution ideas. The objective of the workshop is to bring out a maximum of ideas aiming at involving landowners in forest management approaches aiming at mobilizing wood and to prioritize the

most innovative and efficient ones. This step builds on the previous results to bring out ideas that meet the needs of end-users.

**Table 4:**

Stakeholders mobilized in the first workshop for the creative co-design of solutions phase

| PPPP stakeholder category | Stakeholders                                   | Number of participants |
|---------------------------|--|------------------------|
| Public sphere             | National Center of Forest Property             | 1                      |
|                           | Chambers of Agriculture                        | 1                      |
|                           | State public institution                       | 1                      |
|                           | National Forestry Office                       | 1                      |
|                           | Federation of forest-wood chain professionals. | 1                      |
|                           | Academic research                              | 1                      |
|                           | <b>Subtotal</b>                                | <b>6</b>               |
| Private sphere            | Private forest manager                         | 1                      |
|                           | Contractor                                     | 1                      |
|                           | Representatives of private owners              | 2                      |
|                           | <b>Subtotal</b>                                | <b>4</b>               |
| Population sphere         | Environmentalist NGO                           | 1                      |
|                           | <b>Subtotal</b>                                | <b>1</b>               |
|                           | <b>Total</b>                                   | <b>11</b>              |

2nd step: Fifth collective work to creatively co-design solutions according to "distributed workshops"

We propose a creative co-design of the ideas prioritized in the previous step. While keeping the PPPP logic, we propose to target the most appropriate actors and users to design each solution. We then propose a collective work per identified solution. We can call these "distributed workshops". They are composed of a collective of actors and users adapted to the design of a targeted solution. The creative co-design of the solutions should lead to a kind of "prototyping" of the solutions ready to be implemented and experimented in the real environment of the Living Lab. As an example, we illustrate this step with one of the solutions prioritized by the actors to answer the initial problem. This solution seeks to have notaries and foresters collaborate to direct forest owners to forest managers upon inheritance. A workshop was held to co-design this solution by mobilizing notaries alongside forestry stakeholders with the following composition (Table 5).

**Table 5:**

Stakeholders mobilized in the workshop to co-design the collaboration between notaries and foresters

| PPPP stakeholder category | Stakeholders                       | Number of participants |
|---------------------------|------------------------------------|------------------------|
| Public sphere             | National Center of Forest Property | 1                      |
|                           | Chambers of Agriculture            | 1                      |
|                           | <b>Subtotal</b>                    | <b>2</b>               |

|                 |                                  |          |
|-----------------|----------------------------------|----------|
| Sphère privée   | Independent Notaries             | 2        |
|                 | Representative of the notaries   | 1        |
|                 | Representative of private owners | 1        |
| <b>Subtotal</b> |                                  | <b>4</b> |
| Private sphere  | Environmentalist NGO             | 1        |
|                 | <b>Subtotal</b>                  | <b>1</b> |
| <b>Total</b>    |                                  | <b>7</b> |

## 6. Results

We propose to present the main results of our implementation presented above. Each phase and the main steering steps will be presented as well as the associated intermediate design objects.

### 6.6.1 Planification phase

For the 1st step of the planning phase "Define the guidelines of the Living Lab", we propose to present a visualization of the tool used to define the guidelines of the Living Lab (Figure 6).

#### **Table 6:**

Define the guidelines of the Living Lab

| Parameters  | Key questions   | Our research  |
|---|---|---|
| Initial problem                                     | What is the initial problem at the origin of the Living Lab?  | The problematic deals with the difficulties of management and mobilization of wood in the Vosges private forests without a Simple Management Plan   |
| General objective of the project in Living Lab mode | Why is a Living Lab necessary and meaningful for this case study?   | The hoped-for objective is to stimulate innovation in the private forest property ecosystem, itself connected to the wood mobilization system, in order to improve the management and mobilization of wood in private forests without a Simple Management Plan. |
| Scope of the project in Living Lab mode             | What is the envisaged scope (spatial and temporal) of the Living Lab?   | The spatial scope is the Vosges department.<br>The temporal scope is 3 years (time of the financing of this research work)  |
| Expected participation targets                      | At what point in the innovation process is stakeholder participation planned, and for what purposes specifically? | The stakeholders will be identified and integrated from the planning phase of the Living Lab and will participate in all phases of the process. We will focus on stakeholders from the upstream of the forestry and wood sector, i.e. those                     |

|  |  |  |
|--|--|--|
|  |  | involved in the management, exploitation, valorization and marketing of forest biomass.  |
| Methods of organizing collective work              | How will the collective work be organized within the Living Lab? | We will build on Dupont et al.'s (2015) "workshop process" presented in the second chapter, which includes three steps: Preparation, Workshop Facilitation, and Cross Analysis.  |
| Expected results of the project in Living Lab mode | What are the expected results of the Living Lab?                 | <ul style="list-style-type: none"> <li>- - The creation of tools and measures to involve forest owners in forest management approaches aimed at mobilizing their wood</li> <li>- - Recommendations for public policies and for the actors in charge of their implementation</li> </ul> |

For the second step "Impregnation and understanding of the real environment of the Living Lab and its actors", third step "Mobilization of stakeholders through a public-private-population partnership (PPPP)" and fourth step "Identification and involvement of users", we identified and analyzed the ecosystem of actors according to a PPPP present in our study area. We present in figure 6, a mapping of the actors linked to our project as well as their interest for the project. The closer the actors are to the center (i.e., to the forest owners who are the main users), the stronger their interest in the project.



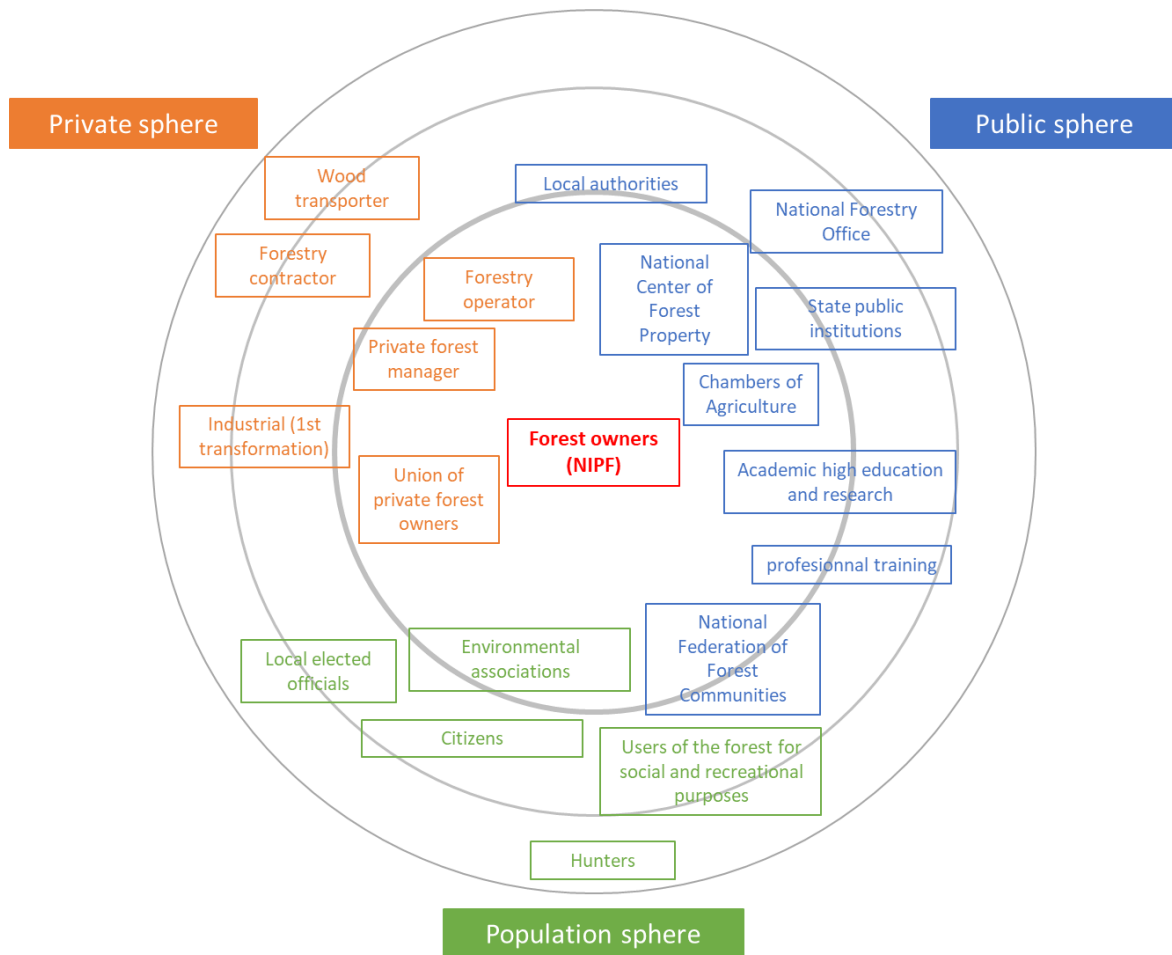


Figure 5: The ecosystem of actors in this project and their interest in the project

### 6.6.2 Exploration Phase

The main result of the exploration phase is the constitution of the shared diagnosis which is composed of three parts:

- The formalization of a collective understanding of wood mobilization in the small private forests of the territory.
- The co-construction of a shared vision on the difficulties to involve private owners in wood mobilization. The actors present indicated the difficulty of approaching and involving private owners in forest management initiatives aimed at mobilizing wood. They identified the main reasons for this as their lack of interest in forest management, the physical remoteness of their property, and the fragmentation of their property which does not allow the implementation of forest management. They indicated that the Living Lab needed to find a way to co-design solutions without necessarily succeeding in involving all types of landowners because this seems very difficult.
- The analysis and characterization of end-users (i.e., NIPF forest owners in the Vosges department). The results are developed in Arnould et al (2021). To summarize, eight forest owner personas were designed: The self-consumer of firewood, The wealth curator, The rational investor, The opportunist, The disinterested, The biodiversity conservator, The recreational and The non-knowledgeable (See Arnould et al., 2021). We obtained an archetype of the different types of owners with an analysis and formalization of their needs, expectations, uses, etc. The personas became the main

boundary object of our Living Lab because they are a tool for collective discussion in our Living Lab to design solutions adapted to the different types of owners. Thanks to the personas, we were able to identify and integrate NIPF owners in the design of solutions (to take into account their needs, expectations and opinions).

### 6.6.3 Creative co-design of the solutions

The wealth curator, the disinterested and the non-knowledgeable, who according to the stakeholders are the owners who do not manage their forest plots. Thus, the stakeholders identified several actions adapted to these three personas. We illustrate this phase with two proposed actions that were prioritized by stakeholders:

- The collaboration between notaries and foresters, which is the main idea of the Living Lab. It is summarized as follows: After an inheritance, many people become owners of forest parcels and do not know how to manage them. The idea identified during this workshop is the establishment of a collaboration between notaries and foresters. Indeed, the actors noted that the notary is the first actor that the new owner meets at the time of the legal act. Thus, the participants of the Living Lab propose to create a collaboration that will allow the notary to redirect the new owners to an organization with expertise in forest management.
- The implementation of Living Labs at the communal level to:
  - Identify "resource" persons at the communal level who could enable the transfer of information to forestry organizations on landowners who have parcels in deficit of management. Very often, in rural villages, citizens know the history of the forest, the owners, etc.
  - Sensitize citizens who do not understand, complain and try to stop wood harvesting activities (in rural areas) when they take place near their residence. For the actors of the workshop, this is a main obstacle to the development of forest management approaches aimed at wood mobilization. The actors are eager to establish a dialogue with the citizens.

## 7. Discussion

### 7.1 The Living Lab approach strengthens collaboration between stakeholders and users to co-create innovative solutions

In order to achieve forest policy goals for wood mobilization, the integration of all stakeholders is essential and necessary to design innovative and quality policy instruments (Lawrence, 2018). It should be noted that improving wood mobilization in NIPF is highly dependent on the involvement and degree of collaboration among stakeholders (Lawrence, 2018). Indeed, the divergent objectives and interests of forestry stakeholders lead to difficulties in timber mobilization (Orazio et al., 2017). For example, there is economic conflict between forest owners and industries, with the former seeking the highest price for roundwood, while the latter try to keep prices as low as possible (Krott, 2005). Or the conflicts between forest resource use and nature protection (Edwards and Kleinschmit, 2013; Teder and Kaimre, 2018). In our study, we faced these same conflicts, but the Living Lab, through its quadruple helix network, PPPP, solution co-creation activities, and consensus building, enables value creation for the mutual

benefit of all stakeholders and end users (Hossain et al., 2019). Without necessarily resolving conflicts and relying on motivated actors who do not stay in their usual postures, we managed to find common ground between stakeholders and end users to design innovative and collective solutions. Moreover, to facilitate these collaborations, the Living Lab takes into account the needs of stakeholders and end-users, which allows to agree from the start on common needs to foster collaborations. Then, our co-creation workshops have fostered collaboration. For each step of the innovation process, we set up co-creation workshops, respecting a diversity of stakeholders who do not share the same opinions and who are often in conflict over forest uses or forest policy implementation. The implementation of this type of collaboration allowed us to think, co-construct and implement responses adapted to the issues and problems of the territories in order to provide territorialized solutions (Roux and Marron, 2017).

In our Living Lab, we integrated a large number of stakeholders (economic actors, environmental advocates, civil society, etc.) with a very high degree of openness, as recommended in the literature on Living Labs (Veeckman et al., 2013). The Living Lab's principle of openness brings together a multitude of perspectives, opinions, and viewpoints to accelerate the development of the process and bring more innovative ideas (Bergvall-Kåreborn et al., 2009). We have involved these actors in a quadruple helix and in the form of PPPP that allow us to bring together people with different but highly complementary skills and knowledge.

Finally, our Living Lab methodology addresses a key element related to the success of projects to improve wood mobilization: trust between owners and stakeholders (Arnould et al., 2021; Lawrence, 2018; Stern et al., 2013). Trust between owners and stakeholders is recognized as an important success factor for timber mobilization in the NIPF (United Nations Economic Commission for Europe and Food and Agriculture Organization, 2020). It is worth noting that forest owners tend to trust those with whom they deal persistently over time, based on common interests, and with whom they have a positive experience (Hujala and Tikkanen, 2008; Stoettner and Ní Dhubhain, 2019). Our Living Lab innovation process, which involves an iterative cycle and co-creation activities, has built trusting relationships between stakeholders and target users (NIPF owners) to improve owner engagement in wood mobilization (Dupont et al., 2019).

## **7.2 Main solutions from our Living Lab to improve wood mobilization in French NIPF**

The implementation of our methodology has allowed us to co-construct solutions to improve wood mobilization in NIPF in France. We will present our two main solutions (those prioritized by stakeholders and end-users) resulting from our Living Lab and currently being tested (It should be noted that other concrete solutions are being considered: carbon valorization, work with local elected officials, a model to help owners reforest, etc.) Indeed, our Living Lab innovation process is currently at the stage of testing solutions, a stage that may last a few months or even years.

First of all, one of the solutions that has been prioritized is the implementation of a collaboration between notaries and foresters to limit the accentuation of fragmentation following the succession of property (Personas: The disinterested, The wealth curator and the non-knowledgeable). We are currently experimenting with this collaboration where notaries redirect new forest owners to a state organization (CNPF or Chamber of Agriculture). This allows us to take direct charge of the owners as soon as they go to the notary's office so that the owner does not isolate himself by not knowing what to do with his forest plot. This solution provides a response to the finding of Orazio et al. (2017) that the increase in plots fragmentation is partly due to inheritance practices and that the legal framework is not adequate to mitigate this effect. Second, another priority solution is to design workshops at the communal level to identify resource persons to help stakeholders learn about and approach NIPF owners. At the local level,

our stakeholder ecosystem indicated that some citizens know who the owners of NIPF are (who owns the plots, who the owners are, where they reside, etc.) and could pass this information on to forest stakeholders to facilitate prospecting and communication. We have started this experimentation in several communes.

These two examples illustrate the results of co-created and prioritized solutions that are currently being tested. These solutions are therefore being accepted, adopted, and tested by stakeholders and forest owners. Contrary to some measures implemented in France, such as some PDM, which are still often contested by local elected officials or even other stakeholders who consider that these mobilization actions are not sustainable (no structuring of the wood market and no long-term forest management) (Sergent et al., 2014). In addition, some forestry operators and experts question the legitimacy of a publicly funded action that favors one operator over others (Sergent et al., 2014). Also, we can cite another example that concerns PPRDF, which seem to have limited effects because they are considered incentive methods based on the voluntarism of a few owners and the goodwill of a few others (François and Vallance, 2019). On the other hand, our Living Lab and our solutions can be articulated with existing systems. For example, the Territory Forest Charters ("Charte Forestière de Territoire" - CFT) that are built on the mode of territorial projects, they become, for the communities that seize them, a tool but also a framework for collective action on the issues of the sector (Lenglet and Caurla, 2020). We believe that the Living Lab methods could be a support to animate and facilitate the CFT. In addition, we also believe that our methodology will improve acceptance, adoption, and use of solutions by NIPF owners and foster collective support and solution development through the establishment of collaborations between different stakeholders. Finally, a reassessment of this research seems to be able to say that it helps foster multi-stakeholder innovation and addresses the identified lack of cooperation among stakeholders that is one of the main barriers to innovation development in the forestry sector (Kubeczko et al., 2006; Hansen et al., 2014). Our study aligns with Lovric et al. (2020) who indicate that successful innovations are characterized by a higher degree of cooperation among stakeholders. Furthermore, through our study, we support the findings of Kubeczko et al. (2006) who indicate that the development of innovations in the forestry sector requires strong cross-sectoral cooperation (example with the collaboration between notaries and foresters).

### **7.3 Main positive impacts of the Living Lab approach on the forest sector and forest policies**

Our study allows us to observe some of the main positive impacts of the Living Lab approach on the forest sector and forest policies. First of all, the main positive impact observed concerns governance in the forestry sector. It is worth noting that the state is increasingly withdrawing from forest governance to make way for the continued emergence of alternative approaches and models that emphasize the role of civil society and market actors (Dobrynin et al., 2020). In this sense, we believe that the Living Lab approach allows a new mode of governance through a PPPP by placing the user at the center of the ecosystem. The governance process in a Living Lab ensures the integration of the innovation ecosystem actors, produces the shared ambition and defines the goals (Leminen et al., 2017). Our study allows us to initiate the first reflections and questions on this mode of governance in PPPP that places the user at the center of the process in the forestry sector. Thus, we provide complementary results to the study by Weiss et al. (2021) by proposing a new governance for the forestry sector in Living Lab mode. But even though the Living Lab appears to be a type of shared and collective governance while providing a structure for perceiving user development perspectives, governance remains

difficult to manage (Hakkarainen and Hyysalo, 2013). This is what we find, as in our study, governance was adhered to until the experimentation stage. It is precisely at this stage of the process that many conflicts and problems emerge between stakeholders. Indeed, at this stage of the process, it is necessary to find a project leader, funders, partners, a perimeter, the agreement of elected officials, etc., and therefore governance in PPPP becomes difficult to respect. Finally, we invite future research to look further into the question of governance in a forestry Living Lab.

Then, the second main positive impact observed concerns the integration of society and citizens in the innovation process of the Living Lab. Citizens are recognized as sources of innovation in Living Labs (Eriksson et al., 2005). Moreover, the literature has highlighted the relevance of co-constructing territorial solutions with citizens, users of the territory, to facilitate the acceptance and appropriation of the innovation on the territory (Glon and Pecqueur, 2016; Klein and Pecqueur, 2017). In our methodology, we therefore included citizens in order to foster innovation and improve the acceptance of solutions by society, especially for wood mobilization, which in some geographical areas of our territory is strongly contested by society and local inhabitants, a finding that agrees with the conclusions of Valkeapää and Karppinen (2013) in their study in Finland. In the future, the Living Lab can help integrate citizens into the development of and response to forestry policies, which will help reduce contestation and misunderstandings. From our study, we believe that it will be easier to integrate citizens into these processes at a local level (for decision making close to their residence). This is because citizens are more concerned with issues in and near their area of residence, in a territory where they have an interest (Kleinschmit et al., 2018). As we continue our research on forest Living Labs, we will be able to observe and explore other positive impacts.

Our research has enabled us to develop and implement a forestry policy to address the issues and challenges related to the forest bioeconomy. Nevertheless, we legitimately ask ourselves the question of a future elaboration of the forestry policy in Living Lab project mode which would allow to mobilize the actors and users from the first reflections of the public action. Especially since Living Labs could represent "a relevant way to create 'socially acceptable' projects, and even more so, effective 'stakeholder-driven' projects" (Lehmann et al., 2015). We believe that when renewing forest policies, a Living Lab approach could be conducted, which would then ensure better stakeholder involvement in the deployment of local actions.

This approach could impulse a "bottom up" sense in favor of a "top down" one. In fact, the Living Lab engages a participatory democracy involving, in particular, society (Janin and Pecqueur, 2017). This participatory democracy seems to be contested by some institutions or private companies, as it may challenge their posture, especially in the forestry sector where society is increasingly seizing these issues and questioning historical practices. So can the Living Lab reconcile citizens with forestry actors? Or challenge existing models to the detriment of forest actors? Living Labs question the posture of institutions and private companies by placing the user at the center of its process. Taking into consideration the needs directly in the real environments of the users seems to be relevant to question the forestry contexts and co-produce a shared vision upstream of the formulation of public action. We could therefore go further by formulating issues with stakeholders and users that would be the basis for future forestry policies. This proposal would also respond to the lack of collaboration identified in the formulation of forestry policies. Indeed, there is little iterative and participatory process and participation is limited to a few actors selected by the state. There is no real common forum where different stakeholders can meet and negotiate a final compromise (Deuffic et al., 2015).

#### **7.4 Replicability and adaptability of the methodology and co-constructed solutions**

First of all, our methodology was designed with a view to being replicated and adapted to other territories, especially with the proposal of the eighth step of our process. But how can our Living Lab methodology be reproduced and adapted to other territories? Indeed, we know that territories are defined as complex and evolving systems with many actors and different characteristic variables (Moine, 2006). Moreover, one of the main questions posed by geographers is to understand how space and location influence practices and actor systems (Agnew and Livingstone, 2011). In addition, timber harvesting is a personal and cultural practice, which leads to difficulties in transferring solutions from one context to another (Rauch et al., 2015; Wippel and Becker, 2008). Despite these difficulties with replication and adaptation of methods, we propose to use our experience to provide some insights into this question.

First, we believe that the role of the immersed researcher must always be that of an orchestrator and facilitator in the ecosystem because developing a Living Lab innovation process requires positioning oneself at the center of the actors and users of the territory. The role of orchestrator allows the integration of the actors and users of the territory at all stages and the role of facilitator allows collaborative work. Moreover, the importance of this role was identified in a pilot project in Auvergne (France) that concluded that the processes of animation and facilitation were the most important factors contributing to success (DRAAF Auvergne et al., 2015).

Second, we believe that the researcher should know as much as possible about his or her study territory, its actors and users (who they are, the relationships between them, their uses, etc.). In order to do this, we recommend carrying out numerous observation sessions in a real context throughout the research project. In our study, we were very regularly in the field, in our territory, with actors and users. Real-life observation allowed us to get to know the actors and users and to interact with them in a formal and informal way. It was then easier to understand their opinions, points of view and preferences in order to integrate them in our Living Lab innovation process and especially in our co-creation workshops.

Third, we believe that it is necessary to use and adapt boundary objects to each phase of the Living Lab and to each project. These objects are necessary to conduct a project in Living Lab mode to formalize data or to capitalize and distribute knowledge to stakeholders, such as personas or the collective understanding diagram of wood mobilization. We recommend that researchers establish a state of the art of all available boundary objects before starting the Living Lab.

Finally, at all stages of the Living Lab innovation process, we believe it is necessary to ensure the inclusion of a diversity of stakeholders and users. We suggest that researchers do not conduct co-creation workshops if this is not respected, otherwise the results could be highly biased.

## **8. Main limitations of the study**

In this section, we will present the main limitations of our study. Our first limitation concerns the difficulties in integrating and soliciting stakeholders to participate in multi-stakeholder workshops. We have noticed that forest stakeholders are increasingly solicited by researchers to participate in participatory approaches and surveys. Some stakeholders told us that they had been over-solicited and had wasted a lot of time responding, with a lack of concrete results in return. As a result, they were less and less willing to get involved in participatory processes. We therefore suggest that researchers solicit stakeholders while planning to provide results that correspond to their needs and expectations so that they can be solicited more frequently by other researchers, as previously reported by Dupont et al. (2014).

Our second limitation concerns action research. Indeed, it can generate biases because the fact that the researcher's roles are fully part of the study can cause a more personal view to become dominant in the observations and exchanges (Donnelly & O'Keeffe, 2013; Baskerville & Pries-Heje, 1999). These roles help drive the innovation process by adapting the methodology to the real environment (Ståhlbröst, 2008), as researchers are the ones responsible for the methodological choices in Living Labs (Schuurman, 2015). Although indeed some authors question the legitimacy of the researcher to occupy these roles, it should be noted that scientific "neutrality" guarantees a certain impartiality that is often recognized by all participants and also brings a necessary trust within the process. As researchers in this study, we do not represent particular economic, environmental or social interests, nor are we direct actors in public policy, which allows us to avoid biasing the results. Indeed, in our study, we tried to be just the orchestrator of the Living Lab without directing the actors towards an idea and without taking sides in the exchanges as previously reported by Schaffers et al. (2009).

Finally, our last limitation concerns the observation in real context of actors and users, as it may involve several biases, including difficulties related to perception and objectivity (Lallemand et al., 2016). Thus, we had to pay attention to two main bias effects: the confirmation effect and the contrast effect (Lallemand et al., 2016). The confirmation effect occurs when the observer retains only those data or observations that are consistent with his or her assumptions or expectations and neglects those that contradict them. As the orchestrator of the Living Lab, we sought to validate our assumptions in order to move the process forward, we also realized that data that did not confirm our assumptions was also very important to our questioning and improvement of the process. The contrast effect occurs when the observer tends to notice only what is salient from previous experiences (Lallemand et al., 2016). Indeed, our observation may have been influenced by the observer's experience. The researcher may sometimes end up with preconceived notions about the forestry sector that may influence our discourse and animation. In the future, perhaps we could observe in a Living Lab with both an expert on the issue and a non-expert present to confront opinions and limit bias.

## **9. Conclusion and perspectives**

To conclude this article, we believe that our Living Lab methodology and its implementation have made theoretical, methodological, and operational contributions to improving wood mobilization in NFIPs. Collaboration between actors and users seems beneficial to co-create innovative solutions, which will be used by owners and deployed by all actors. One of the concluding points we would like to emphasize is that action research in Living Lab mode has improved the perception of the researcher's role by practitioners. Indeed, research is often considered by practitioners as being far from their concerns because the vocabulary and objectives are sometimes different, which makes collaboration between researchers and practitioners very difficult. The Living Lab allows practitioners and researchers to collaborate together to achieve a common goal. We would like to point out that with a researcher in the role of orchestrator of our Living Lab, several practitioners understood what research could bring to their daily activities. Through this study, our first research perspective concerns the question of the adaptability and replicability of our methodology to other territories and issues in the forestry sector. We can already indicate that our methodological framework of reference is already replicated and adapted to other projects whose objective is the co-design of actions of adaptation of forests to climate change, the development of ecological transition in forest territories or the co-design of technical itineraries of forest plantation. These perspectives are necessary to further test the relevance of forestry Living Labs. Our second major research perspective is also similar to a question: Following the funding of our study, how will the Living Lab continue to develop on the territory? And who will develop it? Indeed, it would be a shame

to lose the collective innovation dynamics, centered on the owners, acquired on the territory. Thus, for this second research perspective, our objective is to find other funding to continue the Living Lab on the territory. Furthermore, we can also imagine that the researchers could take on the role of trainer for local authorities and public actors so that they can co-facilitate a Living Lab on their territory. We can imagine a transfer of knowledge and skills from researchers to local authorities who would take on the role of orchestrator of the Living Lab on their territory. Or we can hypothesize that Living Labs can be the source of new private jobs in the territories. Finally, we believe that Living Labs still have an unexplored potential for the development and implementation of forestry policies.

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## Appendix 1 : Overview of the main definitions of Living Labs (inspired by Compagnucci et al., 2021 and Skiba, 2014)

| Authors                                   | Definitions   |
|---|---|
| Ballon et al., 2005                       | An experimental environment in which technology takes shape in real-world settings and in which (end) users are considered co-producers.  |
| Mitchell, cité dans Eriksson et al., 2005 | A user-centered research methodology to detect, prototype, validate and refine complex solutions in multiple and evolving real-life contexts.   |
| Ponce de Leon, 2006                       | A methodology in which innovations, such as new services and products or application improvements, are created and validated in collaborative, multi-contextual, empirical and real-world environments within individual regions.   |
| ENoLL, 2007                               | A system that helps users, including citizens and customers, play an active role as contributors and co-creators in the research and innovation process.  |
| Ballon et al., 2007                       | An experimental environment in which the technology takes shape in real contexts and in which (end) users are considered co-producers.  |
| Feurstein et al., 2008                    | Living Labs are defined as public-private-population partnership (PPPP) collaborations in which stakeholders co-create new products, services, businesses, and technologies in real environments and virtual networks in multi-contextual spheres.  |
| Ståhlbröst and Bergvall-Kåreborn, 2008    | A Living Lab is an intermediary innovation community that shares the viewpoint of a user-driven approach to innovation.   |
| Bergvall-Kareborn et al., 2009            | A Living Lab is a user-centered innovation environment built on practice and research with an approach that facilitates user influence in open and distributed innovation processes engaging all relevant partners in real-world settings.  |
| Commission européenne, 2009               | A user-centered, open innovation ecosystem based on a partnership between business, citizens, and government that allows users to actively participate in the research, development, and innovation process.  |
| Pallot, 2009                              | A user-centered open innovation ecosystem integrating research and innovation within a public-private-population partnership (PPPP) through an iterative experiential design process.   |
| Arnkil et al., 2010                       | A Living Lab is an enhancement or implementation of public and user participation as a public-private-person partnership (4P or quadruple helix).   |
| Almirall and Wareham, 2011                | Living Labs are open innovation intermediaries that seek to mediate between users, research, and public and private organizations, and to advance our concept of technology transfer by incorporating not only user-based experimentation, but also by engaging companies and public organizations in a process of learning and creating pre-commercial demand. |

|                            |  |
|----------------------------|--|
| Pallot et Pawar, 2012      | A Living Lab is a user-centered open innovation ecosystem, integrating research and innovation within a public-private-personal partnership (PPPP) through an iterative process of experimental design.  |
| Dell'Era and Landoni, 2014 | A design research methodology aimed at co-creating innovation through the involvement of conscious users in a real-life setting.   |
| Schuurman, 2015            | Living Labs are an approach to innovation that consists of three distinct but interdependent levels of analysis. At the macro level, they are a public-private-population partnership organized to exchange knowledge and conduct innovation projects. These Living Labs innovation projects are characterized by active user participation, co-creation, multi-method and multi-stakeholder are the meso level. These projects are made up of different stages of research aimed at involving and contributing users to the innovation process, which is the micro level. |
| ENoLL, 2016                | Open and user-centered innovation ecosystems, based on a systematic approach of co-creation with the user, integrating research and innovation processes in real communities and settings, following a multi-method approach.  |
| Mastelic, 2019             | A Living Lab is an innovation intermediary that orchestrates an ecosystem of actors in a specific region. Its objective is to co-design products and services, in an iterative way, with key actors in a public-private partnership and in a real context. One of the outcomes of this co-design process is the co-creation of social value (benefit). To achieve its objectives, the Living Lab mobilizes existing innovation tools or develops new ones.   |

## Appendix 2 : Policy instrument to improve wood mobilization in France

| Publication                                | Policy instrument   | Definition  |
|--|---|---|
| IRSTEA, 2012;<br>Sergent, 2014             | Development plan massif (“PDM – Plan de Développement de Massif”)   | The development plan massif is part of a local development approach for smallholders, allowing them to benefit from: <ul style="list-style-type: none"> <li>• a reduction of the effects of fragmentation (land management, exchange of plots...)</li> <li>• an increase in the harvest with grouped exploitation allowing the marketing of forest products and the reduction of exploitation costs</li> <li>• the construction of collective infrastructures (access roads, wood storage areas, etc.)</li> </ul> |
| ADEME, 2011                                | Regional multi-year forestry development plan (“PPRDF - Plans Pluriannuels Régionaux de Développement Forestier”)           | The regional multi-annual forestry development plan is implemented on a territorial scale to create a match between supply and demand, to boost forest management and wood production while better preserving biodiversity.   |
| Deuffic et al., 2015 ; Orazio et al., 2017 | Authorized syndicated associations (“ASA – Association Syndicale Autorisée”)  | The Authorized syndicated association is a forest management syndicate in France. The objective is to elaborate a simple management plan on behalf of all owners and to carry out the management, equipment and marketing of the forests.   |
| ADEME, 2011;<br>Lenglet and Caurla, 2020   | Forestry charter of territory (“CFT – Charte Forestière de Territoire”)   | The forestry charter of territory is a contractual tool, generally implemented by local communities or local elected officials, whose objective is to bring together all the actors and users of the forest on a given territory and to create the conditions to satisfy the various uses in a sustainable development perspective.   |
| Guillon, 2014                              | Economic and environmental forestry interest group (“GIEEF - Groupement d’Intérêt Economique et Environnemental Forestier”) | The Economic and environmental forestry interest group allows private forest owners to manage their forests in a sustainable and concerted manner by improving the mobilization of wood while taking into account environmental issues on a given territory.  |
| ADEME, 2011                                | Land consolidation  | There are different laws to encourage land consolidation: <ul style="list-style-type: none"> <li>• Right of preference</li> <li>• Right of preference of the commune</li> <li>• Right of pre-emption of the commune</li> <li>• Right of preemption of the State.</li> </ul>   |
| Orazio et al., 2017                        | DEFI devices  | The DEFI in France is an income tax reduction scheme for forest owners who purchase forest land parcels or undeveloped land to be afforested. He measures seem to favor the accessibility to the plots and thus the mobilization. A variety of tax exemptions encourage the implementation of sustainable forest management.  |

|  |   |   |
|--|---|---|
| Centre National de la Propriété Forestière, 2018 | The forest moves (“La forêt Bouge”)   | <p>“La forêt Bouge” is intended to guide forest owners and facilitate their efforts to:</p> <ul style="list-style-type: none"> <li>• locate their parcels with the possibility of creating a map,</li> <li>• describe their forest stands (types of trees, environmental issues, regulatory zones, etc.)</li> <li>• manage their parcels by accessing qualified professionals, knowing the price of wood, or even the possibility of selling or acquiring new parcels.</li> </ul> |
| Centre National de la Propriété Forestière, 2006 | Training in forest management (“FOGEFOR – Formation à la Gestion Forestière”) | FOGEFOR are continuous training sessions in forest management and has been created in the mid 1980s in order to learn forestry to forest owners and in particular “very new forest owners” (basic level) or to improve their knowledge on basic principles  |
| François and Vallance, 2019                      | The Forest Land Grant   | The forestry land exchanges make it possible to stimulate the regrouping of land by encouraging the transfer and exchange of forestry parcels   |

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