TRANSITIONING TO SUSTAINABILITY FOR NATURAL RESOURCE-BASED INDUSTRIES

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ABSTRACT

Natural resource depletion urges us to find new ways of managing natural resources in a more sustainable way. However, developing sustainable innovations to better deploy natural resources does not automatically lead to sustainable practices in the industries. That's why, this article seeks to understand how innovation can actually lead to transition toward sustainability.

To understand how sustainability transitions eventually occur, this article adopts a relational perspective on sustainability transitions and focuses on the practices and discourses that take place within three industries that experience transitions in natural based industry. This shows that transitions occur by reshaping the value of natural resources and restructuring the industries involved. In doing so, this article contributes to a better understanding of the relational perspective on sustainability transitions and draws consequences on how to rethink natural resource management to make it more sustainable.

Keywords:

Natural resource innovation, sustainability transition, relational perspective, sociotechnical systems, multiple case study.

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Natural resource depletion is part grand challenge to solve (George, Howard-Grenville, Joshi, & Tihanyi, 2016) as our growing consumption of natural resources cannot allow anymore their regeneration. The consequence of this phenomenon is that we may pass from a resource abundant environment to a scarce-natural-resource environment, implying to change the way we deploy these resources (Gugissa, Ingenbleek, Van Trijp, Teklehaimanot, & Tessema, 2021). Natural resources take part in all organizations and industries (Figge & Hahn, 2020; George, Schillebeeckx, & Liak, 2015a; Tashman, 2020). So, we focus specially on natural-based industries because they are at the root of every industries (Andersen, Marìn, & Simensen, 2018). Despite these arguments, NRBI seemed to have been understudied because they seemed to be not complex enough be interesting (S. Ville & Wicken, 2013).

Innovation is often seen as a response to the imperative of new development for natural resource-based industries (Andersen et al., 2018). However, these innovations do not necessarily trigger radical transition toward sustainability, and even sometimes perpetuate a business-as-usual perspective (Figge & Hahn, 2020). Beyond the path dependence regarding innovation adoption, one of the many reason is the difficulty to understand the impacts of innovation and measure them (Rimos, Hoadley, & Brennan, 2014). Some research start understanding the condition transformation of NRBI into sustainable industries, among which the wind energy industry (Russo, 2003). However, we don’t know yet the micro-mechanisms that explain how sustainability transitions in natural resource-based industries occur. Hence, the aim of this article is to respond to the following question: *How do sustainability transitions occur in natural resource-based industries?*

To answer our question, we focus on transitions 'in the making' that allow us to understand the mechanisms that may eventually lead to a transition (Elzen, Geels, Leeuwis, & van Mierlo, 2011). It involves the adoption of a relational perspective that assumes that the process through which transitions occur involves actions from sociotechnical systems, which consist of networks of actors, institutions, artifacts, and knowledge that interact to create the transition (Callon, 1986; Diaz, Darnhofer, Darrot, & Beuret, 2013; Farla, Markard, Raven, & Coenen, 2012; Garud & Gehman, 2012; Markard, Raven, & Truffer, 2012). We specifically focus on the mechanisms embodied by human (de Haan & Rotmans, 2018) and non-human actors (Contesse, Duncan, Legun, & Klerkx, 2021) in their practices and discourses (Smith & Raven, 2012).

We explore three natural resource-based industries that transitioned the cut-flower industry, the fishing industry, the textile fiber industry. Both these industries developed *natural resource innovation*, meaning they rely on alternative natural resources. This innovation triggered radical transformation within these industries. We find that the initiation and spread of sustainability transitions involve both reshaping the value of natural resources and restructuring industry. The resulting process model contributes to understanding how natural resource-based industries can build their transition toward sustainability.

This article is organized as follows. The first section reviews the literature on natural resources innovations and sustainability transitions by developing its evolutionary and relational perspectives and by unpacking the practices and discourses inherent to transitions. The second section showcases the three studied transitions and describes the methods that we use to understand how natural resource-based industries trigger sustainability transitions. We present our process model in the third section by focusing on the initiation and spread of sustainability

transitions and discuss this in the last section with reference to sustainability transitions in natural resource-based industries.

NATURAL RESOURCE-BASED INDUSTRIES AND INNOVATION FOR SUSTAINBILITY

Natural resources are defined as *"stocks of materials that exist in the natural environment that are both scarce and economically useful in production or consumption, either in their raw state or after a minimal amount of processing"* (World Trade Organization, 2010: 46). They comprise finite resources that once depleted are not available for future use (Bastian, Richter, & Tucci, 2018) and natural resources such as water, land, crops, timber, and fisheries, etc., even though renewable, are also subject to depletion (Mildner, Lauster, & Wodni, 2011). The growing consumption of natural resources will conduct to a "peak", meaning a starting point where production can no longer meet the demand and lead to depletion (Prior, Giurco, Mudd, Mason, & Behrisch, 2012). Depletion concern, of course, nonrenewable resources but renewable ones as well.

Why the case of natural resource-based industry is important when talking of natural resource depletion? All industries are, at one point or another, depending on natural resources (Prior et al., 2012). So, natural resource depletion in particular urge natural resource-based industries to question their responsibility regarding the natural environment and how to take care of it. Several responses are developed to face the challenges of natural-resource depletion and pollution. Among them, natural resource-based industries seek innovation to improve their environmental impact (Cristina De Stefano, Montes-Sancho, & Busch, 2016). For example, some research seeks to understand how to be resilient in scarce natural resource market (Gugissa,

Ingenbleek, van Trijp, Teklehaimanot, & Tessema, 2021). They show how resource scarcity can trigger, not only product innovation but also process innovation, inviting academic research to open our conception of innovation regarding sustainability. However, research shows the complexity to fight against natural-resource depletion as the impact of innovation for natural resource preservation is difficult to measure (Rimos et al., 2014).

Some research indeed suggest not to focus only on innovation but more broadly into innovation systems (Bélis-Bergouignan & Levy, 2010) in order to understand how innovation can actually trigger sustainable practices. However, only a few work explores sustainability transition in the case of the NRBI despite the fact they that sustainability transitions do not apply exactly the same way with NRBI (Andersen & Wicken, 2016). Some studies looked for the conditions of the emergence of this transition such as the influence of natural, social and economical influence (Russo, 2003) or the strategy of actors depending on their position within the industry (Stalmokaitė, Larsson Segerlind, & Yliskylä-Peuralahti, 2023).

To understand how such transitions operate, we build on the sustainability transition literature, as this research field has concentrated on the change in natural resources at the core of some industries, for instance, in energy from coal to natural gas (Rimos et al., 2014) or from fossil resources to fuel cells and hydrogen technology (Budde, Alkemade, & Weber, 2012).

UNPACKING THE MECHANISMS OF SUSTAINABILITY TRANSITIONS

The sustainability transition literature assumes that sustainability changes are accomplished through radical innovations leading to shifts in sociotechnical systems toward more sustainable modes of production and consumption (Geels, Elzen, & Green, 2004; Geels & Schot, 2007; Kemp, Schot, & Hoogma, 1998; Markard et al., 2012; Rip & Kemp, 1998).

To understand how sustainability transitions occur, the multilevel perspective on sociotechnical transitions focuses on the interplay of dynamics at the niches level, which are protected spaces in which radical innovations can develop without being subject to the selection pressure of the prevailing regime (Kemp et al., 1998), the sociotechnical regime, which highlights the social embeddedness of scientific knowledge, practices, and technologies that follow the logic and direction for incremental sociotechnical change (Kemp et al., 1998), and the landscape, which are the factors that can put pressure on existing regimes and open windows of opportunities for niches to break through and contribute to fundamental changes, or shifts, in sociotechnical regimes (Geels, 2002; Geels & Schot, 2007).

To understand the mechanisms leading to sustainability transitions, we adopt a relational perspective on sustainability transitions (Diaz et al., 2013; Garud & Gehman, 2012; Geels, 2010).

A relational perspective on sustainability transitions

A relational perspective on sustainability transitions assumes that due to the resistance and conflicts inherent to sustainability transitions, accomplishing a *sustainable journey* does not involve a linear shift from one equilibrium state to another but the continuously negotiated accomplishment of the actors and objects entangled with one another (Callon, 1986; Garud & Gehman, 2012). For instance, in focusing on the emergence of the Danish wind cluster, Garud and Karnøe (2003) found that the cluster had developed through cocreation and through the interweaving of resources across multiple arenas of use, production, regulation, and evaluation in a dynamic of improvisation, adaptation, and bricolage, allowing new ideas and directions to emerge during the whole process.

To do so, a relational perspective does not make differences between ‘levels’, as it adopts a ‘flat ontology’ and denies distinctions between agency and structure or ‘micro’ and ‘macro’ due to the adoption of actor network theory (ANT) (Callon & Latour, 1981; Diaz et al., 2013; Garud & Gehman, 2012; Geels, 2010). A relational perspective also perceives humans and things as mutually constitutive (Callon, 1986; Latour, 2005). This allows a focus on the resistance and conflicts that occur during the emergence of sociotechnical systems, leading to shaping the environment in action to promote sustainability transitions (Diaz et al., 2013; Garud & Gehman, 2012).

Sociotechnical systems are composed of actors who seize opportunities to transition (de Haan & Rotmans, 2018; Farla et al., 2012). They include formal networks (Musiolik & Markard, 2011), social movements and civil societies (Penna & Geels, 2012) (Enthoven & Thelken, 2023), organizations (Konrad, Markard, Ruef, & Truffer, 2012) (Schaltegger, Loorbach, & Hörisch, 2023), policymakers (Grin, Rotmans, & Schot, 2011), etc. Their roles and relations with other actors evolve over time (Wittmayer, Avelino, van Steenbergen, & Loorbach, 2017). The ANT captures these interactions by following these actors’ shifts over time (Callon & Latour, 1981; Diaz et al., 2013).

Sociotechnical systems are also composed of non-humans that often crystallize transitions (Contesse et al., 2021); these systems can include mushrooms or lentils in regard to studying transitions based on a shift of natural resources. They play a role in transitions, as expressed by Contesse et al. (2021), who showed how the *Bagrada hilaris* pest created and intermediated relationships, changed the roles of other actors and disrupted their sociotechnical system, and compelled new actors to join the pest sociotechnical system.

To understand the actions that human and non-human actors undertake during sustainability transitions, we focus on practices and discourses.

The practices and discourses that constitute sustainability transitions

Sociotechnical systems are enacted through practices and discourses (Smith, Stirling, & Berkhout, 2005). Practices are visible through the processes of negotiation and enrollment that sociotechnical systems engage in (Genus & Coles, 2008). They first include problematizing the issue that actors want to defend, which entails framing the very definition of sustainability and the journey required to achieve it (Callon, 1986; Garud & Gehman, 2012). As the actors and objects that constitute sociotechnical systems are very diverse, they have different and sometimes conflicting frames. Thus, enrolling actors in sociotechnical systems leads to framing contestation and involves adapting the frame over time (Callon, 1986; Garud & Gehman, 2012). Interested actors within the sociotechnical system also include actors promoting the project and the alignment of the interests of actors through *'displacement, drive, invention, mediation, the creation of a link that did not exist before and that to some degree modifies two elements or agents'* (Latour, 1994: 32).

Sociotechnical systems also emerge from the discourses of the actors who promote sustainability transitions (Rosenbloom, Berton, & Meadowcroft, 2016). They can stand on a d*iscourse of fit and conform* where actors convince the broader social world that the new sociotechnical system can become competitive with conventional system criteria (Smith & Raven, 2012). In this case, discourse can build on *'practices that were shelved, abandoned or even stigmatized as mistakes'* (Garud & Gehman, 2012: 986). In contrast, the promotion of the sustainability transition can also stand on a d*iscourse of stretching and transforming* to convince the wider social world that the rules of the game need to be changed (Smith & Raven, 2012). The

promise of the new sociotechnical system presented to each actor must have an appeal to instill confidence and commitment to enroll them. For instance, Geels and Verhees (2011) describe how it was necessary for nuclear power to be adopted in the Netherlands in the 1950s and 1960s to match regulations and rules and be accepted by the broader public and fit with existing societal norms and beliefs.

To understand the mechanisms through which sustainability transitions occur within natural resource-based industries, we focus in this article on the practices and discourses that perform sustainability transitions, and we develop, in the next section, the method that we used to analyze them.

METHODS

As we aim to study sustainability transitions in natural-based industries, we study transitions 'in the making' that occurred in three industries by focusing on the mechanisms that may eventually lead to a transition (Elzen et al., 2011).

Case justification

We focus on three natural resource-based industries for which the question of sustainability transition has been strongly pointed out through scientific reports: the fishing, fresh-cut flower, and textile fiber industries. For example, for the fishing industry, a report published by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services offers the following statistics:

> *'In 2015, 33% of marine fish stocks were being harvested at unsustainable levels; 60% were maximally sustainably fished, with just 7% harvested at levels lower than what can be sustainably fished'* (United Nations, 2019).

In these three industries, we found initiatives that had developed sustainable strategies based on innovation by changing natural resources they rely on, in the industry, we call that *natural resource innovation*. For instance, for the fishing industry, we focused on an initiative called *Poiscaille* aimed at shifting from common species to 'forgotten' species less subject to pressures on their stocks. As shown in Table 1 and developed in the next subsection, the other cases show similar frame.

Insert Table 1 about here.

Case presentation

From common to 'forgotten' fishes. While more than 90% of fish stocks used to be harvested at higher levels than what can be sustainably fished, most governments around the world have allocated catch limits for the most endangered species. However, these quotas may not be radical enough to allow for the renewal of fishing stocks. Some initiatives have developed to tackle the issue, as is the case of a French startup, *Poiscaille*, which connects more than 200 fishermen and fisherwomen with 13,000 customers throughout France to sell 'forgotten' species, i.e., fish species that are currently neglected by consumers despite offering unique flavors to alleviate stocks of the most endangered species.

From exotic to local fresh-cut flowers. The fresh-cut flower industry is seen as harmful to the environment, as cut flowers are usually cultivated in low-revenue countries under opaque conditions. To combat these practices, an initiative called the *Slower Flower Movement* was born in the US to encourage sales of locally grown cut flowers with high sustainability standards and

develop a network throughout the country. Similar sustainable entrepreneurial movements have flourished in other countries, as is the case, for instance, in France with the *Collectif de la Fleur Française*.

From cotton to French hemp and wool. The textile fiber industry mostly relies on cotton. However, this fabric has been denounced as detrimental to the environment. Given the stigmatization of cotton, hemp has resurfaced, as it is heartier, requires 10 times less water than cotton to grow, and does not require the use of pesticides. Different initiatives have burgeoned across France, such as *Virgocoop, LCBio* and *La Chanvrière*, which aim to rebuild the French hemp industry. Wool can also be used as an alternative to cotton. While sheep need to be sheared each year to stay healthy, the price of wool does not cover the price of shears, and wool is perceived as a wasted material. The Tricolor Project was thus born as an initiative aimed at rebuilding and valorizing the French wool industry for textiles, as is the case for the cooperative *Ardelaine* and organization Tricolor project.

Data collection

To understand the mechanisms through which actors and objects contribute to constructing a new sustainable sociotechnical system, we collected documents that we complemented with primary data.

Documents. To gain a general understanding of the sustainability transitions that have occurred in the three studied industries, we first relied on historical books, academic articles, and investigation books to comprehend their historical development. For instance, scrutinizing the history of hemp helped reveal the importance of the fiber prior to the 19th century (Deitch, 2003) and thus the newness of the sociotechnical system organized around cotton fiber.

Once the context understood, we focused our data collection on the actors and objects that contribute to the sustainability transition (Contesse et al., 2021; de Haan & Rotmans, 2018; Farla et al., 2012; Garud & Gehman, 2012; Raven, Verbong, Schilpzand, & Witkamp, 2011; Wittmayer et al., 2017). For each studied initiative, we systematically collected press articles using search engines Factiva and its French equivalent *Europresse* using relevant keywords. For instance, for the textile fiber industry, we typed into both search engines the names of the organizations involved in the initiative such as 'Virgocoop' and then typed 'hemp + textile' (and the French equivalent). Using snowballing techniques, we then followed the actors and objects of the studied sociotechnical systems and collected additional press articles and website pages (e.g., corporate websites) based on our readings (Callon, 1986; Latour, 2005). For instance, we found that the sociotechnical system of the hemp industry includes not only the *Virgocoop* but also the Hemp Act, *Atelier Tuffery*, and *Passe-Trame*, which have developed their own practices and discourses within the sociotechnical system. We thus typed these names into the search engines and looked for relevant information on the corporate websites. Overall, we collected more than 1,000 articles related to the initiatives of the three investigated industries with details on specific events, snapshots on certain actors, descriptions of initiatives, the viewpoints of some actors, etc.

For some initiatives, we also collected additional public information. For instance, for the case of cut flowers, we read the blog entries written by Debra Prinzing, the journalist who initiated the *slow flower movement* in Seattle, published since the blog's creation 2007, and we read the Slow Flowers Journal. For the fishing industry, we collected all weekly newsletters published by *Poiscaille* called *Radio Ponton* (literally 'radio pier' in French) from the beginning of 2019 (more than 130 as of November 2021). Finally, we collected documents advertising different initiatives, such as booklets.

Primary data. Primary data were used to corroborate the collected information. First, we attended tradeshows to understand the practices and discourses of the incumbent sociotechnical systems. Tradeshows are considered *'arenas in which networks are constructed, business cards are exchanged, reputations are advanced, deals are struck, news is shared, accomplishments are recognized, standards are set, and dominant designs are selected'* (Lampel & Meyer, 2008: 1026). For the textile fiber industry, we attended in 2020 the professional tradeshow *Première Vision*, the leading tradeshow of the clothing fabric industry (see Rinallo & Golfetto, 2006), where we collected booklets (see above), listened to discourses of the industry, visited exhibitors' stands and talked to some industry actors. For the textile fiber and fishing industries, we attended the French agriculture tradeshow of 2020 targeting the general public to grasp the general discourse on sustainability transitions.

We also attended in 2020 the Made in France Première Vision tradeshow, a tradeshow specialized in local French textile brands, where we gathered discourses from initiatives willing to achieve sustainability transitions. This helped us differentiate between the peculiarities of transitions based on a natural resource innovation from broader sustainability initiatives.

Finally, for some initiatives for which we could not follow actors relying on documents alone, we also interviewed them. For instance, we conducted a series of interviews with the founder of *Poiscaille*, who helped us move beyond secondhand information to improve our understanding of the activities that had occurred within the sociotechnical system of 'forgotten' fishes.

Data analysis

We relied on grounded theoretical methods (Strauss & Corbin, 1990) and analyzed our data over four steps. We first immersed ourselves in the documents and primary data to understand, for each investigated industry, the discourses of actors and their actions to implement natural resource innovation. For each initiative, we wrote a 10-to-15-page comprehensive report in which we focused both on the industry context and on the actions put in place by the actors of the industry. The aim was to synthesize our important dataset to achieve a common understanding between the two authors. To ensure the validity of our syntheses, we communicated this first step of the investigation through teaching cases and through a practitioner-oriented article that we shared with the actors we were in contact with. This cross-comparison of the three studied industries led us to recognize several commonalities between our cases to be investigated further. For instance, we found that the studied initiatives were present in the industry in the past but have since been discarded, as the case of the hemp industry highlighted above shows. We also found a common rhetoric based on the intrinsic properties of the new natural resource that was more sustainable. As we found these elements intriguing, we decided to develop them further by systematically analyzing the common themes present in the three industries in an inductive manner.

Thus, using the Gioia method (Gioia, Corley, & Hamilton, 2013), in a second analytical step, we inductively analyzed our data through open coding by focusing on the practices and discourses taking place among sociotechnical systems. For instance, we found that to gain value in the eyes of customers, the natural resources from the three investigated industries had to be compensated with other resources. We developed this idea under a first-order category that we

labeled ‘bundling natural resources.’ By cycling through the codes and comparing them, we finally identified recurring codes, which we collapsed into 16 first-order categories.

In the third step, we searched for relationships between first-order categories to understand how natural resource innovation led to transitions. We identified 6 additional themes. For instance, we were struck by the idea that in all of our cases the initiatives had developed but kept at a local scale; thus, we formed a second-order theme called ‘Replicating small-scale initiatives’ based on the following three first-order findings ‘Keeping the initiative local,’ ‘Multiplying local initiatives,’ and ‘Gathering a community.’ We then linked the phenomena that emerged from the three cases by integrating the second-order themes into two aggregate theoretical dimensions based on our observation that some of the actions were rooted in the discourses of actors that correspond to ‘Reshaping natural resource value’, while others were rooted in their practices that correspond to ‘Restructuring industries.’

Finally, in the fourth and last step, we used the six second-order themes to build provisional models. We refined them over multiple iterations, returning from time to time to the data until we achieved our final process model composed of two sequential phases: ‘initiating the sustainability transition’ and ‘spreading the sustainability transition.’ To link the themes, we also thought of terms that would best express the relationships. For instance, we drew an arrow from ‘Determining new value for the natural resource’ to ‘Acquiring necessary skills’ with the term ‘Embody’ to show that skills are the means through which actors and objects determine the value of natural resources. This step completed the research process from data collection on innovation on natural resources aimed at achieving sustainability transitions to the theoretical constructs that we developed (see Figure 1 for the data structure and Table 2 for additional quotes for natural resources not mentioned in the text).

Insert Figure 1 and Table 2 about here.

TRANSITIONING TO SUSTAINABILITY

Building on data from three natural resource-based industries, this section describes sustainability transitions 'in the making' by focusing on the initiation and spread stages (see Figure 2).

Insert Figure 2 about here.

Igniting sustainability transitions

We found that igniting a sustainability transition involves four activities that we describe in turn as follows: determining new value for the natural resource, acquiring the necessary skills, implementing the new value chain, and establishing a proof of concept.

Determining new value for the natural resource. As sustainability transitions are problematized by implementing a natural resource perceived as more sustainable than the incumbent resource, we found that actors who operate the transition initiate the change by determining new value for the alternative natural resource that will differ from the previous one. The first argument from our cases lies in building on the intrinsic properties of natural resources that differ from those of incumbent natural resources. For instance, in the transition from the cultivation of exotic to local flowers, the slow flower movement does not build that much on arguments of beauty and low prices, which are the discourses of proponents of exotic flowers, but rather on locality. As flowers are local, they are accustomed to the weather conditions where they are displayed and are

fresher than exotic flowers that have undergone several days of air transportation prior to being sold. As a consequence, local flowers please clients who favor longer vase life (Stewart, 2008).

Natural resources also determine their value through their contrast to incumbent resources' value in terms of sustainability. For instance, hemp is often compared to cotton, as the extract below from an open editorial illustrates:

> *Other brands have chosen to rethink the materials they use to produce their clothes. Instead of cotton, whose cultivation causes environmental damage as regularly criticized, they prefer hemp, which is reputed to be more ecological.* (Le Monde, January 20th, 2021)

Finally, even if the intrinsic properties of new natural resources confer them an advantage in the market, the overall value offered by the new sociotechnical system may be lower than that offered by the prevailing system. Offering a comparable or better advantage for customers thus implies bundling natural resources with other resources and capabilities. For instance, the Tricolor project – an organization dedicated to developing the use of French wool in the textile industry – epitomizes how to build a credible competitive advantage through the bundling of resources. The initiative promotes clothes produced entirely in France. For consumers, buying wool clothes from the Tricolor project means supporting the French economy and French know-how. In addition, as every step of production is local, consumers buy clothes with a lower carbon footprint than regular clothes usually produced far away from where they are worn. Thus, the Tricolor project builds not only on the intrinsic properties of wool and on its superiority in comparison to cotton but also on the value of the capabilities associated with wool, which is here determined from the Made in France label, which has become quite trendy in the last decade. However, to embody this new discourse that aims to reshape the value of natural resources, we found that it is necessary to acquire skills to restructure the industry accordingly.

***Acquiring the necessary skills*.** Initiating the sustainability transition involves acquiring the skills needed to restructure the industry and provide newly determined value. We found that this first involves obtaining new technical skills. For instance, as *Poiscaille* offers 'forgotten' fishes based on a subscription model for which customers choose their combination of fishes and shellfish online, the start-up had to make IT developments, as subscription models such as this one does not exist on the shelf (Interview with the CEO of *Poiscaille*). In 2021, the organization published the following job advertisement:

> *Alongside a team of two full-stack developers (including the CTO) and a UX designer, you will design, prototype, develop, test and operate all applications developed internally. Your scope is wide: from the declaration of a fisherman's catch, its marketing on our e-commerce site, to the preparation chain of each customer order and its after-sale follow-up. All our tools are tailor-made (in-house e-commerce framework). […]* (welcometothejungle.com, retrieved in August 2021)

The need for IT skills illustrates a shift within the fishing industry toward a sociotechnical system of 'forgotten' fishes requiring the involvement of new types of actors, objects, and skills.

We also found that some skills cannot be acquired externally, as they are not available or are difficult to find on the market. In this case, know-how is rediscovered from forgotten practices, as was the case for slow flower movement:

> *We, the people, are finally embracing local, sustainable, and quality,* everything*. We're once again growing our own flowers for our own homes. It shouldn't come as any surprise that the matriarchs – the vintage flowers of our past – are calling to us. (McLaughlin, 2018: 7)*

As the above book extract shows, traditional know-how involves relying on heirloom varieties of flowers that used to be locally cultivated and requires involving local flower growers that have a specific interest in these varieties, rediscovering archives to understand the varieties that used to be cultivated, interviewing elder flower growers to identify the best varieties, etc.

Finally, skills can be acquired by importing ideas from other industries. For hemp, *LCBio,* the society of organic flax and hemp, first believed that it could take advantage of the experiences of the flax sector to develop hemp for cultivation and launched a series of tests. However, the synergies between the two plants were found to be limited. For instance, while *LCBio* was first willing to harvest hemp with flax harvesting machines, it eventually found that they were not compatible (Paris-Normandie, June 3rd, 2019). Restructuring the industry does not, however, rely only on acquiring the necessary skills. The next subsection turns to the implementation of the new value chain.

***Implementing the new value chain*.** We found that implementing a new value chain composed of the new sociotechnical system involves building on the capabilities necessary to make things work. To form the sociotechnical system at the core of the new value chain, different skills, people, and objects must be combined. For instance, for the hemp industry, *Virgocoop* developed as a sociotechnical system gathering all the necessary skills and capabilities needed to renew the hemp industry in the Occitanie region of France. The organization combines capabilities from *Atelier Tuffery* that manufactures blue jeans *'with a new business model: direct sales from the producer to the consumer'* (Le Figaro, May 11th, 2018), *Passe-Trame* that specializes in the weaving of the fiber, Hemp-Act that aims to turn the fiber into threads, etc. These actors build on the skills previously described and are thus diverse, as some come from other industries or are new to the industry. For instance, *Passe Trame* comes from the wool industry, and Hemp-Act was created in 2013.

We also observed that the different initiatives have enrolled actors within the industry value chain. For the fishing industry, *Poiscaille* actors use specific strategies. As fishermen and fisherwomen discard 'forgotten' fishes, as they are sold at a price that is so low that they prefer

throwing them overboard when they are caught, *Poiscaille* offers them some value. The start-up also buys fishes at a constant price on average 20% higher than the market price. These strategies have been particularly powerful in convincing fishermen and fisherwomen to work under the sociotechnical system embodied by *Poiscaille* during the COVID-19 pandemic, as the following excerpt from *Radio Ponton* shows:

> *'It is a good thing we have Poiscaille.' This message from Jean-Philippe Gallas sums up fishermen's and fisherwomen's recognition of the volumes valued in the previous week. Indeed, the situation is improving for the sailors only on a temporary basis. Some auctions are still closed […], and prices are at the grassroots. Restaurants are still at a standstill, and the Spanish market is still slow. The Minister encourages fishermen to go back to the sea. However, it is impossible to respect distance onboard. How can fish sold for 3 to 4 times less than usual and many unsold fishes be handled? The already poor cash flow following a winter that has almost come to a standstill is barely going up. Several fishermen and fisherwomen go out only for Poiscaille. In Arcachon, we pushed for the organization of an additional sale last Wednesday: three fishermen/fisherwomen were able to sell their large fish catches from Tuesday without waiting. In short, we have had a real positive effect in this extraordinary situation.* (Radio Ponton #56, April 12th, 2020)

The fourth mechanism initiating the transition to sustainability relies on establishing proof of the possibility of both reshaping the value of natural resources and restructuring the industry, as developed below.

Establishing proof of concept. Establishing proof of the possibility of shifting natural resources first involves demonstrating its technical feasibility. In all of our cases, proof was obtained from discourses embodied in several artifacts: books, web TV shows, podcasts, tradeshow attendance, interviews, etc. For instance, to show that it is technically feasible to craft local flower bouquets throughout the year, even in the winter, Debra Prinzing, one of the actors of the *slow flower movement* in the USA, published a book in which she crafted a different bouquet made of local flowers for each of the 52 weeks of the year (Prinzing, 2013). Following this project, she launched on her blog a contest to encourage people to take pictures of their weekly bouquets.

Establishing a proof of concept also involves demonstrating the economic viability of the new model of natural resource management. Shifting to a new natural resource must be a financially viable strategy for the sociotechnical system that helps it achieve sustainability purposes. For instance, the CEO of *Poiscaille* explained that profitability is at the core of his organization. Between 2017 and 2018, income increased, and the start-up reached a *'fragile economic balance.'* At the end of 2019, the CEO raised funds to accelerate the growth of 2020 and increase financial viability (Interview with the CEO of *Poiscaille*). While the financial models of our cases are diverse, we found that sociotechnical systems have developed a long-term strategy that builds on economic profitability.

In the end, all of the observed initiatives intend to stay on a sustainable track over the long run. For instance, in considering the need to find alternatives to cotton in the fashion industry, the French government mandated a report to the strategic committee of the fashion and luxury industry *(Comité Stratégique de filière mode et luxe)* to study ways to support sustainable fashion. The report notes the following:

> *[T]his mission has allowed, by the number of solicited interlocutors and despite the diversity of actors within the industry and the difficulties related to the health crisis, to confirm the strong commitment of everyone on these major issues and to identify common convictions:*
> *- Interest in sustainable fashion is a fundamental trend for all market segments.*
> *- Rethinking its business model is essential to meet the new market challenges.*
> *- Promoting Made in France means promoting France's image, the excellence of its know-how, and supporting local employment and development.* (Comité Stratégique de filière mode et luxe, 2020)

Despite offering multiple means of achieving sustainability in the fashion industry, the example above illustrates how they converge to reach the sustainability imperative. Once proof of concept is achieved, sustainability transitions spread.

Spreading sustainability transitions

We found that spreading a sustainability transition involves crystallizing the value proposition and replicating small-case initiatives.

***Crystallizing the value proposition*.** To spread sustainability transitions, the studied initiatives crystallized their value propositions by making specifications that maintain their sustainable purpose, forging an identity for sustainable initiatives. As specifications aim to present and describe initiatives' objectives, we observed that formalization usually takes the form of a few bullet points. For instance, slow flower movement was encapsulated in 2017 in a manifesto and developed according to the following five key ideas:

> *Slow flower movement is committed to the following practices:*
> - *To recognize and respect the seasons by celebrating and designing flowers when they naturally bloom*
> - *To reduce the transportation footprint of the flowers and foliage consumed in the marketplace by sourcing as locally as possible*
> - *To support flower farmers, small and large, by crediting them when possible, through proper labeling at the wholesale and consumer level*
> - *To encourage sustainable and organic farming practices that respect people and the environment*
> - *To eliminate waste and the use of chemical products in the floral industry*
>
> (Slow Flower Journals, April, 14th 2017)

Crystallizing the value proposition also involves embodying the initiatives. Any actor or object from the sociotechnical system can embody an initiative, including organizations, people, or artifacts. For the fishing industry, Charles Guirriec, the CEO of *Poiscaille*, has become a spokesperson for the start-up by, for instance, being interviewed on national radio as a sea expert, as shown below:

> *From the Normandy coasts to the Breton shores, it's flatfish season! Lessons and recipes with the sea expert Charles Guirriec and the chef Thibault Sombardier*. (France Inter, February 21st, 2021)

Based on their crystallized value proposition, the initiatives are then replicated on a small scale.

***Replicating small-scale initiatives*.** We found that all sustainable initiatives maintained a philosophy of local anchoring, were replicated accordingly, and gathered a community. The initiatives first developed at a small scale and involved linking actors in their territory, either regional or national. For instance, *Philea Textiles*, a fabric designer of the hemp industry, has kept its production local, as its founder explains below:

> *I refuse, and I will always refuse, the fatalism of the delocalization, in words and in acts, says Philippe Schmitt [who created Philea Textiles, which manufactures viscose fabrics]. However, it is not up to me to pay alone for the rehabilitation of the whole sector that has tragically disappeared... It is necessary to resuscitate it, from the spinning mill to the final fabrics, by innovating and by polluting less!* (Le Figaro, June 25th, 2019)

As the above extract shows, spreading initiatives do not involve gaining economies of scale or delocalizing. Instead, it involves reinforcing the sociotechnical system in the territory, i.e., *'resuscitat[ing] it'* as the extract explains.

However, working at a local scale does not mean that the sustainability transitions must be kept small. As the slow flower movement has become a global movement operating in the USA, Australia, and in some countries in Europe, it provides a good illustration of how it has expanded while adhering to its initial philosophy of locality. For instance, the following extract discusses the launch of slow flower movement in Australia:

> *[Ms. White] is an advocate of the 'slow flower movement' and wants to create more consumer awareness to buy local, seasonal, and bee-friendly flowers. To connect like-minded farmers across Australia, she founded the Consortium Botanicus group and aimed to promote small-scale, ethical, and sustainable farming practices.* (Australian Broadcasting Corporation New, May 30th, 2019)

Interestingly, while Ms. White explains that her initiative is locally anchored in Australia, it follows the specifications of the US's slow flower movement described above.

Finally, we found that replicating small-scale initiatives relies on gathering a community within the industry. For instance, for the fishing industry, *Poiscaille* aims to strengthen its ties with fishermen and fisherwomen. Even if the start-up ironically questions its capacity to *'make of Poiscaille the first fishing marriage agency'* (Radio Ponton #120), it organizes frequent meetings with the fishermen and fisherwomen of its network to share information it has access to thanks to its national coverage (interview with Charles Guirriec; Radio Ponton #120). During two months in 2021, *Poiscaille* also organized a *Tour de France* of the network to better understand the fishermen and fisherwomen who are part of it (Radio Pontion #130-#134). To create this sense of community, *Poiscaille* finally envisions financing the installation of independent young fishermen and fisherwomen to support the industry (interview with Charles Guirriec).

DISCUSSION AND CONCLUSION

This article builds on cases of natural resource-based industries to develop a process model of sustainability transitions. We discuss our findings in relation to the sustainability transition literature. By using the relational perspective on sustainability, our research unpacks the process that eventually leads to transitions. These observations also allow us to draw conclusions on how to develop an industrial sustainable management of natural resources.

The benefits of a relational perspective on sustainability transitions

Our research applied a relational perspective on sustainability transitions to explain the mechanisms through which transitions unfold following an innovation based on a new natural resource. Applying this ontology allowed us to understand 'transitions-in-the-making' (Contesse et al., 2021) and put the focus on the mechanisms leading to potential sustainability transitions (Callon & Latour, 1981): the innovation must be followed by a series of actions to make the

transition work. As historical narratives, in contrast, offer a long view that informs that innovations do not automatically lead to transitions, this demonstrates the complementarity between the two ontologies to the study of sustainability transitions.

Studying the mechanisms leading to sustainability transition leads us to discuss the growth model of transitions based on natural resource innovation. While the linkage between degrowth and sustainability transitions has already been suggested (Khmara & Kronenberg, 2020), we show that transitioning implies not ‘less’ but something ‘different’ (Banerjee, Jermier, Peredo, Perey, & Reichel, 2020). The transitions to sustainability based on a natural resource innovation that we observed led to an offered value that differs from the previous value and that does not compare to it. Enrolling stakeholders in new sociotechnical systems imposes proving them benefits that go beyond ‘green’ benefits. To have hemp producers switch from one industry to another, they must rely not only on sustainable arguments but also on arguments related to the producers themselves. In regard to consumers, as the products being sold must draw interest in their eyes, we observed that the perceived value must differ from rather than compete with the prevailing value. Local flowers do not compete with exotic flowers on the beauty criteria but on vase length criteria and perfume, for instance. Overall, our research anchored in the relational perspective of sustainability transitions shows that the new growth that transitions induce not only involves production and consumption changes or localism (Khmara & Kronenberg, 2020) but also induces an alternative – and not a lower – value proposition. In other words, the studied transition necessitates a change in the value offered by the industry, which is enacted through discourses and practices.

Our analysis of the micro aspects of transitions also led to an understanding that natural resource innovation alone does to provoke transitions. We observe experiments where actors first

demonstrate the technical feasibility, economic viability, and sustainability advantages before making specifications to maintain the sustainable purpose and communicating on them to overcome the resistances inherent to prevailing systems. Understanding the necessity to demonstrate the benefits of transitions contributes to a better understanding of transition experiments for which the emphasis is put on learning (Sengers, Wieczorek, & Raven, 2019). This article presents transitions to sustainability as ongoing journeys with trial-and-errors that go on throughout the process. We thus argue that the idea of enrolling actors inherent to the relational perspective on sustainability transitions (Callon, 1986; Garud & Gehman, 2012) brings new knowledge to the literature on experiments.

Finally, our research centered on a specific type of non-human actor: natural resources. While Contesse et al. (2021) focus on the evolving role of non-human actors in developing a sociotechnical system, our article shows the incidences of a change of non-human actors in a given industry in terms of discourses and practices. In other words, we show that the role of non-human actors is not that much in undertaking the change but in triggering the change. In line with Contesse et al. (2021), we show that non-human agency acts as a 'transformer' as it transforms practices and discourses within the sociotechnical system. The transformation is led by the human and non-human actors who constitute the sociotechnical system. This gives a broader role to agency in sustainable transitions than the role already envisioned and nuances the power of the agency of human actors (Wittmayer et al., 2017).

Overall, this research built on the contribution by Garud and Gehman (2012) to show that a relational perspective on sustainability transitions improves our understanding of sustainable transition growth models, experiments, and the role of non-human actors.

Natural resource-based transitions

Natural resources (and natural resource based industries) are at the core of industrial activity (Bélis-Bergouignan & Levy, 2010; Keupp & Gassmann, 2013; Prior et al., 2012; Rimos et al., 2014). Their preservation has even been defined as a 'grand challenge' to be addressed by scholars (George, Schillebeeckx, & Liak, 2015b). However, despite increasing evidence showing that the industries that contribute to their depletion should tackle the issue themselves (Keupp & Gassmann, 2013; Prior et al., 2012; Rimos et al., 2014), understanding how to manage natural resources in a sustainable way remains limited. For instance, in the agricultural domain, while transitions have been suggested toward more sustainable agricultural futures (Bui, Cardona, Lamine, & Cerf, 2016; Pigford, Hickey, & Klerkx, 2018), the emphasis on natural resources in innovation systems has been overlooked (with the exception of Bélis-Bergouignan & Levy, 2010).

To bridge this gap, our research linked sustainability transitions with natural resource management. While prior research has already emphasized the importance of integrating the analysis of natural resources in innovation systems, for instance, by showing how dependence on a natural resource exerts a deep influence on an innovation system (Bélis-Bergouignan & Levy, 2010), we show in this research how a natural resource innovation can be at the inception of sustainability transitions and depict the mechanisms leading to an eventual transition. Natural resource management can then be linked to sustainability transitions: developing new models of natural resource management involves developing sustainability transitions.

Therefore, we call for questioning the source of value creation and competitive advantage considering natural resource preservation. First, the source of competitive advantage is traditionally conceptualized as internal to the firm and based on the control of some resources by

the firm (see Barney, 1991; Wernerfelt, 1984). We believe that this statement pushes firms to focus on endangered resources to create more value for themselves. However, our research shows that the transition 'in the making' creates value for the whole sociotechnical system, customer included, by offering a value based on natural resources that are not depleted. Bundled with other resources, they create a new credible value in the eye of the market. Second, our research shows that transitioning based on new natural resources involves managing natural resources not from an organizational perspective but from an industry perspective, as different actors from the value chain take part in the sociotechnical system that contributes to the transition. Overall, our research shows that the sustainable management of natural resources involves a reevaluation of the value of natural resources and their collective management. Given the depletion of natural resources, its lack of research in management (George et al., 2015b), and the growing field of sustainability transitions (Markard et al., 2012), we can only call for more research at the intersection of sustainability transitions and natural resource management to continue improving our understanding of how to manage natural resources sustainably.

Practical implications

Our research finally offers practical outlook. Examples of natural resource innovation spread among industries, such as insects for the food industry, or vegetal leather for the textile industry. However, focusing only on natural resources without questioning the whole industry is not enough to accomplish a sustainable transition. If we want this transition to occur, our article shows that during the first stages of transitions, it is necessary to offer new value to natural resources and to recreate the value chain of the industry with new actors and capabilities. If such deep changes are not made, there is a risk that the new natural resource does not lead to sustainable transition because the 'business as usual' would apply.

Given the inherent mobilization of actors, activities, knowledge, tools, etc., if we want these new value chains based on sustainable natural resources to work, we recommend investing in the coordination of the networks needed to construct new value chains offering more sustainable products and services. Particularly, we found that it is important to support industrial associations as they gather actors from the industry toward a common sustainable goal, to pay attention to the 'outsiders' willingness to transform industries who are not subject to organizational inertia and to develop incentives toward learning from other industries or from past practices, as they may offer some clue toward sustainable futures.

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FIGURES AND TABLES

Table 1: Justification of the cases

Industries	**Example cases**	**Natural resource innovation for sustainable purposes**
Fishing	*Poiscaille*	Innovate from common to 'forgotten' species
Fresh-cut flower	*Slow flower movement, Collectif de la Fleur Française*[1]*,…*	Innovate from imported to local flowers
Textile fibers	*Virgocoop, LCBio, La Chanvrière, etc.*	Innovate from cotton to hemp
	Tricolor project, *Ardelaine, etc.*	Innovate from cotton to wool

1. [1] This is French for the *Collective of the French Flower*.

Table 2: Dimensions, Themes, Categories and Quotes

Second-Order Themes and First-Order Categories	Representative Quotes
Overarching dimensions: initiating sustainability transition	
1. Determining new value for the natural resource	
A. Building on resources' intrinsic properties	A1. Merino wool benefits: moisture management, breathability, temperature regulation, odor resistant, easy care, stain resistant, UV protection, fire resistant, and elastic. (Merino wool brochure, printed in 2019) (wool) A2. Dory Tabet, the owner of a supermarket, sees about twenty customers coming to pick up boxes filled with fresh and varied seafood products. 'The formula immediately appealed,' says the shopkeeper. (Leparisien.fr, March 15th, 2017) (fish)
B. Contrasting with current dominant resource	B1. Locally grown flowers are at the opposite end of the environmentally friendly scale to imported varieties, which account for about a quarter of Australia's massive cut-flower market. Flower imports, which have increased dramatically in the past decade, are heavily treated by chemical processes to be eligible for import under Australia's biosecurity safeguards. (Geelong Advertiser, November 12th, 2018) (cut flowers) B2. Atelier Tuffery […] created the first jeans in the fall of 2018 that included 48% wool. 'I use Lacaune from the Causse Méjean, which is washed in Haute-Loire, spun in Mazamet, woven in Castres and made in Lozere, explains Julien Tuffery. It's local, unlike globalized cotton.' (Les Echos, March 20th, 2019)
C. Bundling natural resources	C1. It is a website and a platform. The latter offers fresh seafood products from sustainable fishing. Fish and seafood are ordered from fishermen and distributed and delivered to the partners relay points. (L'Est Républicain, December 6th, 2017) (fish) C2. Slow flowers connect consumers with the source of their flowers, putting the human face of the flower farmer and floral designer behind each bouquet or centerpiece. The value of local, seasonal and sustainably grown flowers is heightened when there is transparent origin labeling of all botanicals sold to consumers and professional florists. (Slow Flowers website, retrieved in August 2021) (cut flowers)
2. Establishing proof of concept	
D. Demonstrating technical feasibility	D1. In Camargue, cooperative ABC Chanvre also faced difficulties setting up its project. […] A sunflower grower finally agreed to do the first cultivation tests of a hemp plot with ABC in 2019.

	The aim of this test was to prove to other farmers that it can work. Students from Montpellier SupAgro also took part in this initiative to find optimal cultivation solutions on Camargue soil. (La Provence, July 28th, 2019) (hemp)
	D2. In another particularly bad week for weather, several fishermen mentioned it had been 'the worst autumn in a long time.' For example, Benjamin Argelas, who recently visited the Bay of Arcachon, said that there were barely 10 days at sea in October, 3 days in November, and 5 days in December. The shellfish, and mainly scallops, save us and allow us to maintain supplies. We are waiting for the return of good weather, which does not seem to be on the menu for the coming weeks. (Radio Ponton #43) (fish)
E. Demonstrating economic viability	E1. According to a 2019 survey by CGS, one third of consumers will pay up to 25 percent more for a sustainable product; thus, the slow flower movement is bound to grow, especially when you consider that in many instances, slow flowers are even less expensive than the alternatives. (Slow Flowers, October 28th, 2019) (flower)
	E2. We must 'take the time to build the economic model,' which will be stabilized within 10 to 15 years. Indeed, the current cost of jeans from the Tuffery workshops is 60 € (compared to 4 € in Asia). Thirty percent of this cost is made up of the price of the raw material, and the rest is made up of the cost of labor. Thirty-five percent of the margin is dedicated to marketing, shipping, and employee training. The remaining 15% of the gross margin is reinvested in the development of the company: R&D, to improve the production processes of models made from new materials (including hemp but also wool) and the future expansion of the workshop. In this way, the company self-finances its expansion. (France Inter, October 27th, 2019) (hemp)
F. Staying on the sustainable track	F1. The cooperative is working on mastering the retting of the straw (maceration to facilitate the separation of the filamentous bark from the stem). 'This is a crucial step. We leave the hemp straw on the ground for five to eight weeks. It is a natural solution, in contrast to that used by the Chinese who make textile hemp with a chemical retting.' (L'Union, May 29th, 2018) (hemp)
	F2. Her [Christine Hoffman's] advocacy has put her at the forefront of what is known as the 'slow flower' movement. With approximately 85 percent of flowers sold in the U.S. grown overseas, where labor is inexpensive and regulations often laxer, the slow flower movement aims to build a more robust consumer market for American-grown flowers that focuses on seasonality. The floral industry—like many others—is built around unnatural expectations of abundance,' Hoffman said. 'Building this new model is meant to offer a more sustainable alternative and to support a viable local flower economy.' (Star Tribune, June 18th, 2018) (cut flowers)
	F3. The development of short supply chains for seafood products is necessary to ensure food safety of Europeans and to guarantee that they can consume quality fish from sustainable fishing. The success of initiatives that bring together small fishermen and consumers, promoting sustainable fishing techniques and lesser-known species, shows

	the economic, social and environmental interest of such an approach. (Le Journal du Dimanche, June 8th, 2020) (fish)
3. Crystallizing the value proposition	
G. Making specifications to maintain the sustainable purpose	G1. 'HUMAN SIZE: Vessels of up to 12 meters with no more than 3 men onboard for small-scale fishing. Day trips. GENTLE TECHNIQUES: Line, trap, straight net, diving, fishing on foot techniques. No trawling or dredging. Selective fishing, preserved seabed. NOTHING IS REJECTED: 'Fished and handled with care, all species preserve their qualities. Known or forgotten, at home, they are all valued.' (Poiscaille website, retrieved in August 2021) (fish)
	G2. [...] we invest today directly in: - The reinforcement of organic agriculture for the exploitation of hemp, textiles, and food, for farmers inclined toward a sense of social utility. - The structuring of a first transformation unit for textile hemp, via the company Hemp-Act, which we cocreated with Pierre Amadieu, an expert in the hemp industry. - The development of the use of textile hemp with the edition of 100% hemp denim fabrics with our partner Tuffery and the textile manufacturers present in the New Aquitaine and Occitanie regions. (Virgocoop website, retrieved in August 2021) (hemp)
H. Embodying the initiative	H1. Debra Prinzing is a Seattle-based writer, speaker and leading advocate for American-grown flowers. Through her many slow flower brand projects, she has convened a national conversation that encourages consumers and professionals alike to make conscious choices about their flower purchases. (Debra Prinzing blog, Retrieved in August 2021) (cut flowers) H2. The Tricolor project encourages the rebirth of French wool industries. Première Vision, in partnership with Made in Town, is making a range of ecoresponsible textiles available to brands and designers who wish to explore the multiple possibilities of this locally produced, short-circuited material in France. (Made in Town Website, Retrieved in August 2021) (wool)
Overarching dimensions: spreading sustainability transition	
4. Acquiring necessary skills	
I. Relying on new technical skills	I2. The Chanvrière [cooperative] has achieved two major innovations. The first is a cottonized fiber (20% hemp and 80% cotton) manufactured on cotton looms. The second is a combed-carded ribbon of 100% hemp. (L'Union, May 29th, 2018) (hemp) I2. The relationships between the farmers and florists are what makes their floral designs one of a kind, as they constantly try new varieties and color palettes to showcase the best Wisconsin has

	to offer. (Debra Prinzing Blog Episode 439, February 5th, 2020) (cut flowers)
J. Rediscovering traditional know-how	J1. 'The renewal of the sector is marked by the delicate question of restoring forgotten know-how. However, the training of the valorization of wool is confidential. The Lainamac network offers a course on wool. […] The sector has been neglected by the general agricultural industries,' says Mélusine Flament, Lainamac's training officer. Generally, not all sheep technicians at the chambers of agriculture are not at familiar with wool. 'There is no teaching on wool in the general fields,' confirms Audrey Desormeaux. Specific sheep certificates do address the question of shearing, but do they address wool? There is work to be done on this question, because avoiding certain bad practices will make it possible to better valorize this product. (Reporterre, June 16th, 2018) (wool)
	J2. You talk about hemp cultivation as something completely new. It is, however, part of a millenary culture in Brittany. However, it has been completely forgotten: the way of harvesting, of storing in bunches... We are going through the archives that deal with the issue. Sometimes we find information: the method, for example, of retting the hemp to make yarn. (Ouest France, June 27th, 2018) (hemp)
K. Importing ideas from other industries	K1. This is the sea version of the vegetable boxes. We have all heard about short circuits and Amap (associations for the maintenance of peasant agriculture), which mainly concern vegetable products. Fanny Agostini is interested this Monday in the products of the sea. (Europe 1, March 2nd 2020) (fish)
	K2. The 'slow flower' movement logically follows the 'slow food' movement and the popularity of healthy, locally grown fruits and vegetables. (Green Thumb, August 9th, 2012) (cut flowers)
5. Implementing the new value chain	
L. Combining the necessary capabilities to make things work	L1. To guarantee a delay of forty-eight hours between the moment the fish comes out of the water and its delivery, the platform works directly with sixty fishermen with sustainable practices, using vessels of twelve meters maximum, no trawling, no dredging in fishing gear, day trips, and no more than three sailors on board. (Le Parisien, October 12th, 2018) (fish)
	L2. The Michigan Flower Growers' Cooperative is a member-based cooperative of flower growers in Michigan and northern Ohio. Members of the cooperative sell wholesale and retail flowers, foliage, succulents and other ornamental plants to florists, floral designers, and wholesale distributors who want fresh, high-quality local products at competitive prices. (Michigan Flower Growers' Cooperative website, Retrieved in August 2021) (cut flowers)
M. Convincing actors to join the initiative	M1. 'The regulations have not supported the development of French wool, and this explains the industrial vacuum […]. This regulation wrongly equates greasing wool with a Category 3 byproduct, in the same way as blood or leather, with draconian storage, handling and circulation

conditions that are very difficult to comply with,' the source explains. As Pascal Gautrand insists, 'We must convince industrialists to take a renewed interest in this noble material.' (L'Usine Nouvelle, May 1st, 2019) (wool)

M2. In the end, it was the farmers interested in growing hemp who notified us: 'If you have outlets and you can guarantee a price per hectare, we will grow all the hemp you want!'… We went to meet Atelier Tuffery, a 'jean maker' who immediately liked our project. Tuffery embarked on the adventure by releasing the first prototypes of pants [made of hemp]. (Virgicoop website, retrieved in August 2021) (hemp)

6. Replicating small-scale initiatives

N. Keeping the initiative local

N1. A number of organizations promote local flowers, and [Jennie] Love [from Love 'N Fresh] sees some confusion between American and locally grown flowers. 'I think it is important not to muddy the waters for the average consumer and keep the message focused on finding a local farm near you, so your purchase power goes toward supporting your community.' (Slow Flower, October 1st, 2016) (flower)

N2. 'We would prefer the added value to remain in France and for our industry to benefit from it. Moreover, consumers have high expectations of organic and local products,' emphasizes Nathalie Fichaux [the Interchanvre director]. The label 'Chènevis of France' should be created this fall to promote the origin of the seeds. (Process Alimentaire, July 1st, 2019)

O. Multiplying local initiatives

O1. Ifa is not the only brand to be interested in hemp. If the textile industry is still in its infancy concerning hemp, initiatives are multiplying. (Les Echos Executives, December 18th, 2019)

O2. Secretary General of the ITU Sud (Union of Textile Industries) Richard Ico sees in this approach an illustration of a will of valorization that transcends borders. 'We see similar approaches appearing in neighboring countries, such as Belgium and Germany,' explains the manager. 'However, it is necessary to keep in mind that French livestock is not, for the moment, bred for clothing. In addition, we can hardly imagine changing livestock for that […]. In fact, these materials must also look beyond clothing to products like furniture and decoration.' (Fashion Network, March 8th, 2019) (wool)

P. Gathering a community

P1. Last year [In 2014], she [Debra Prinzing] created a directory of farmers and florists who specialize in American-grown foliage. It now has 600 members. (International New York Times, October 16th, 2015) (cut flowers)

P2. From a mapping of the sector as it exists today in the country, Tricolor approaches the professional actors one by one, creating a label within a year for the moment.' Pascal Gautrand continues to explain, 'we are asking breeders and processors to certify

transparency. This should allow us, within a year, with the partnership of the national federation of sheep, to structure a collective brand, like a label guaranteeing quality. The challenge is to go to the end of the chain to involve the players one by one right up to the final consumer.' (Midi Libre, October 3rd, 2019) (wool)

Figure 1: Data structure

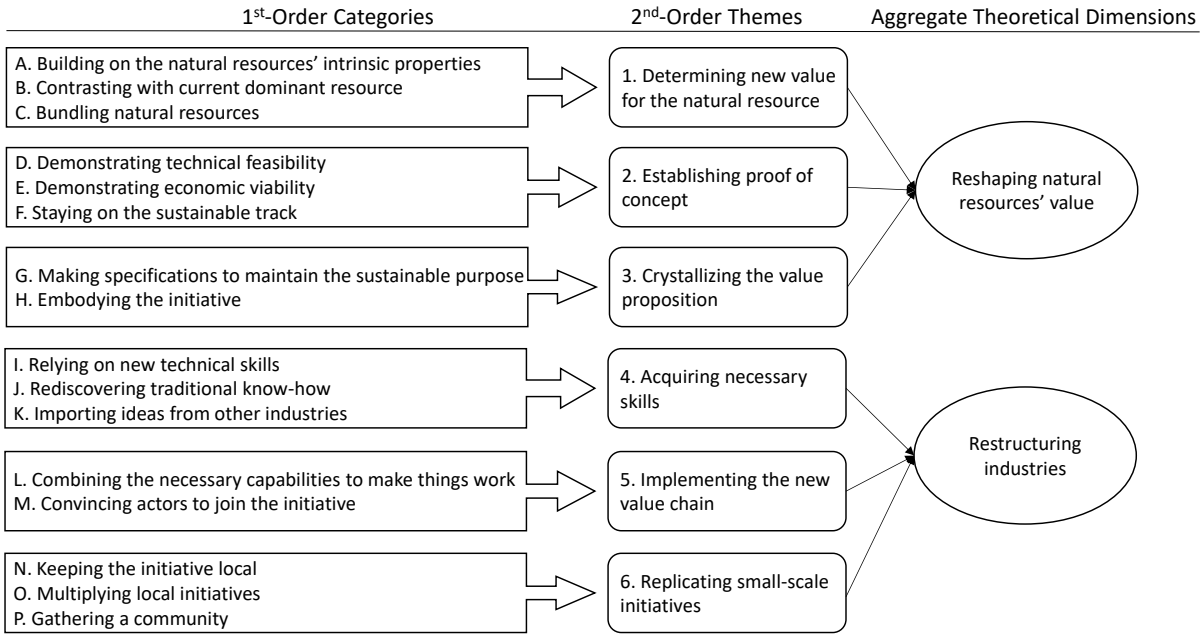

Figure 2: Process model of sustainability transitions based on natural resource innovation