Living vs. Zombie technologies as a framework for innovating in the era of the anthropocene

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RESUME :

Malgré l'augmentation de la littérature sur les modèles d'affaires, la théorisation du concept doit encore être liée à la limitation planétaire. Sur la base d'une recherche collaborative avec un projet technologique Deeptech, nous montrons que l'innovation à l'ère de l'anthropocène nécessite d'élargir notre vision de ce qu'est la technologie.

En reliant la littérature sur l'innovation des modèles d'affaires et les technologies vivantes, nous explorons un projet agricole DeepTech basé sur les technologies vivantes, et nous suivons l'évolution de l'élaboration du modèle d'affaires.

Nous contribuons à la littérature sur l'innovation en présentant la notion de technologie zombie vivante comme une ressource solide pour réfléchir à l'innovation. Cette recherche affine également le concept de technologie zombie en montrant l'impact de l'arrangement socio-technique environnant et la littérature sur le BM durable en montrant l'impact des relations avec l'écosystème entrepreneurial dans la transformation de la proposition de valeur.

MOTS CLEFS :

Living technologies, DeepTech, Business model, Value proposition, Anthropocene

INTRODUCTION

Humanity has entered the anthropocene, a geological era in which the effects of human actions on the earth have been demonstrated (Crutzen & Stoermer, 2000), particularly in climate and natural settings. This overall context implies efforts to adapt our societies to fit planetary limits (Steffen et al., 2015)) hence attenuating climate change.

The institutionalisation of climate issues is taking place at all governance levels (Chateauraynaud & Debaz, 2017) and the latest report of the IPCC (Intergovernmental Panel on Climate Change) points out the weaknesses of actions implemented so far (Intergovernmental Panel on Climate Change, 2023) but it also shows that solution to attenuate climate growth already exist.

Among human activities at stake in the anthropocene, farming is targeted as one of the areas where effort must be made (Intergovernmental Panel on Climate Change, 2015) to fit climate constraints. Since the 50's natural solutions have been replaced by chemical and genetic solutions at the expense of already existing technologies that fit better with the environment such as Biological control[1].

The French Agency of Development (AFD) recognises that climate disruption represents an industrial challenge (2017) and identifies DeepTech innovation as a means to overcome it. DeepTech is defined as the production of innovation based on intensive R&D activity engaged for quite a long time. Therefore research, whether public or private and start-ups engaging in it are capital and time-intensive.

[1] 'The use of Living organisms to suppress the population density or impact of a specific pest organism, making it less abundant or less damaging than it would otherwise be' (Eilenberg, Hajek and Lomer, 2001)

According to the French Deeptech Observatory (2021), around 11% of Deeptechs belong to the "Greentech" category, which groups start-ups developing cutting-edge innovations offering a technological breakthrough to meet ecological challenges. Biological control has recently gained interest and is now associated with DeepTech since its development requires time and important investment.

For Greentech, building business models meets several challenges. They must overcome technological hurdles to solve constraints linked to environmental issues, and also those linked to access to an emerging and evolving market due to the evolution of knowledge on environmental transformations.

Relying on a theoretical framework characterising technologies concerning their fit with planetary limits this paper shows that farming is a good example of Techno transformation based on Zombie/Living technology.

Our first research question is: *Why can the concept of Zombie and Living technologies provide a fruitful framework for managing innovation in the era of the Anthropocene?*

Our paper proposal concerns biological control research and aims to study the process of developing a business model in the environment of a Greentech project for agriculture.

The case under scrutiny delves into the effective use of resources to bring their technology closer to market. We will show that thinking considering the Anthropocene implies not only reassessing negatively perceived resources but also modifying the framework for evaluating resources in a way that considers the resource lifecycle impact on natural ecosystems.

Our second research question is: *How to empirically use the concept of Zombie/Living technologies to further a transition in agriculture under which conditions ?*

1. THEORETICAL BACKGROUND

The Anthropocene, climate change as well as recent health and geopolitical crises, are driving us to reconsider the framework for evaluating the impact of innovation on planetary limits. These successive events lead to resource depletion thus one could reconsider the usage of resources because of anticipated limited availability or shortage.

We will focus on the rise of the concept of innovation and its potential connection to the Anthropocene era. To do so, we (i) link the notion of innovation to the Anthropocene era, (ii) and look at the notion of business model innovation.

1.1. Innovation in the Anthropocene

1.1.1. Innovation, techniques and planetary limits

Among the eight inception hypotheses of the Anthropocene era proposed by Wallenhorst (2021), Crutzen advances the first industrial revolution (Crutzen & Stroemer, 2000) as a relevant timing. It concurs with John Rae's (1834) view on foundations of the Economics of Innovation that seeks to identify the nature and causes of innovations (e.g., the steam engine) and to assess the effects of technological progress on the economic growth of nations.

Innovation is a very recent term, but the idea of technological advancement and induced changes is already a focus of economists such as Ricardo and Veblen, who ultimately connected science and technology through the roles of engineers that generate technical progress (Coccia, 2018). Although the concept of innovation has broadened (e.g., social innovation), it remains confined to a technical dimension (Godin & Vinck, 2017).

Innovation is thus traditionally perceived as a positive and beneficial force for the economy and Humanity. Because traditional factors such as work and capital could not explain economic growth during the Second Industrial Revolution, Schumpeter hypothesised that

innovation could explain this growth. Over time, this hypothesis has evolved into a truth (Aggeri, 2023) and as a panacea for politics (Godin, 2013).

Innovations are commonly associated with well-being and the extension of the human lifespan. We argue that this perspective has hindered our ability to recognise the negative consequences of innovation particularly those concerning planetary limits and our prosperity.

Bonnet, Landivar, et Monnin (2021), introduce the notion of *desinnovation* which implies the dismantling of technologies and associated facilities regarding planetary limits. This process can be done with a "*desincubation*" process. The entrepreneurship field is composed of experts such as lawyers, business angels and certified accountants who contribute to developing start-ups and small innovative businesses. All of them have the competency to disassemble emerging technologies both organizationally and strategically. However, rather than "*desincubation"* we observe that in the realm of innovation, deeptech has replaced the term innovation but serves the same purpose and means : growth based on the use of finite resources taken from the natural setting.

Another perspective close to that of Bonnet et al (2021) is what Goulet and Vinck (2012) call withdrawal innovation. They coined this notion based on the idea that innovation is commonly manifested through the addition of novel elements. This inclination to perceive innovation exclusively in terms of adding novelty is termed the bias of "introduction-of-something" (Godin & Vinck, 2017, p110). Innovation can thus manifest itself as withdrawal, as observed in practices such as adopting pesticide-free agriculture. Withdrawal innovation entails a sophisticated social process involving the mechanisms of delegitimating, disqualification, and dissociation concerning associations, visibility, or invisibility. Goulet and Vinck (2012) emphasise that innovating by withdrawing and dissociating involves complex mechanisms in which human actors actively seek to qualify

themselves and the entities with which they interact. This approach emphasises a more nuanced understanding of innovation beyond the mere addition of novelty, aligning with a broader scientific comprehension of the innovation process.

We will now propose a novel view of technology that has the potential to foster and trigger the development of strong sustainable innovations.

1.1.2. Living/Zombie Technology as a Framework for thinking sustainable innovation

In this paper, we aim to provide open ways to define and manage sustainable innovation. To do so, we mobilise a theoretical framework that offers a classification of technologies with their impact on planetary limits: the Zombie versus Living technologies framework.

This emerging theoretical framework classifies properties of technologies in regard to their capacity to ensure human and other Living entities cohabitation on earth. According to José Halloy et al. (2020, p 120), technologies must be analysed within the framework of the "anthropocene". The question then is whether a technical system is sustainable from an ecological perspective over a long period, in opposition to technical systems that have detrimental effects due to their impact on non-renewable resources and /or natural settings.

Following this, sustainability is reframed as the materials, all kinds of processes (production, development, maintenance…), and activities that can last in the long term without depleting non-renewable resources particularly carbon-based fossil origin (coal, oil, gas) or even using it (Halloy et al, 2020). This Framework has been formalised by Monnin (Bonnet et al., 2021) as follows and differentiates technologies between Zombie and Living ones (Table 1).

	Resources	Sustainability	End of Life
Zombie Technologies	Finite (long-term exhaustion)	Minimum durability in working order	Maximum life span as waste
Living Technologies	Renewable (strong sustainability)	Maximum durability in working order	Minimum life span as waste

Table 1: translated from Monnin (2021, p.21)

Monnin (2021) highlights that Zombie technologies are non-recyclable, and when this is the case, it implies the use of a huge amount of fossil energy that makes it ecologically inefficient.

As Landivar (Bonnet et al., 2021) advances, innovations in terms of both outcomes and processes contribute to creating, developing, and maintaining attachments to practices that are hindering planetary limits. One must attenuate the effect of innovations as products and processes. Relying on the Zombie/Living technology is a way to bring a new understanding of what innovation is and how it can evolve to fit planetary limits.

Nowadays, the place of research on sustainable technologies over the long term remains very marginal in France and the AFD (2017) associates the climate problem with an industrial matter; they point out the role of DeepTech in solving it. The term DeepTech has emerged recently, it is a form of public or private research valorisation that implies a long period to develop and a large amount of money. Most of the solutions cited as having the potential for DeepTech are high-technologies that are expected to change the world (Nedayvoda, 2020). However, these technologies are mostly digital ones and or use non-renewable raw materials for their production (Drones, Satellites, AI…). One can consider that in this configuration, they belong to the realm of "Zombie technologies" since they demand a variety of resources such as minerals and rare-earth elements for their elaboration, energy for their use through digital networks, as well their recyclability is not taken into consideration yet.

So far innovation remains obstinately riveted to finite resources without taking into consideration the life cycle analysis of such artefacts. In this paper, we link the need for the emergence of sustainable technologies by integrating the notion of Living technology into the logic of innovation. To do so, we rely on the concept of business model and in particular on the definition of the value proposition of technology based on Living technology.

1.2. Business model design and the value proposition of technologies in the era of the Anthropocene

Our approach is at the crossroads of strategy, innovation and entrepreneurship since we are interested in the process of crafting business models for Deeptech start-ups dealing with environmental issues. We focus on agricultural innovations that have sustainable potential: the overall activity of agroecology and in particular the implementation and use of biological control.

1.2.1. Business model: a pluralist concept with potential for sustainability

The Business model concept (BMC) was initially developed by practitioners (Warnier et al., 2018) and it took time before it diffused to the research arena. The literature developed since then identifies several uses: first, as an analytical framework to assess established companies and industries (Chesbrough & Rosenbloom, 2002; Kraemer et al., 2000; Krueger et al., 2004) second as a strategic tool that encompasses both market and non-market elements (Ranjatoelina, 2016; Warnier et al., 2013) and associated organisational concepts (Demil & Lecocq, 2010). When used as a strategic tool, Massa and Tucci (2014) refer to meta-models of Business models as they are more detailed and reflect the complexity of interactions that must be taken into consideration. They turn out to be a useful tool for developing innovative ventures (Demil & Lecocq, 2015; Massa & Tucci, 2014), however, the resulting theorising has been influenced by a typological approach to business models, that helps to set the

contours of the concept (Massa et al., 2017) but can appear as reductive. This point might be an element that brings Bonnet (2021) to associate Business models as a negative commons, we believe that this view of business model held quite well to the concept when it is comprised of archetypes and graphical frameworks, "have shortcomings in their inability to offer a full account of the dynamic aspects associated with a particular BM" (Massa and Tucci, 2014, p 433) it is particularly the case when types of BM are interpreted as "one best ways" (Warnier et al., 2018). Massa & Tucci (2014) argue that meta-models of BM "may help to overcome this problem" (p. 433) because they allow for creativity in the analysis of strengths to define original configurations.

Massa et al (2017) identify three roles of BM: BM as an attribute of real firms, BM as cognitive/linguistic schemas and BM as formal conceptual representation/descriptions. When using the concept of business model, we refer to it as a conceptual representation that can further the development of organisational and industrial sustainability as advocated in the literature (Massa et al., 2017; Massa & Tucci, 2014). Integrating the concepts of sustainability and business model has important consequences since it implies assuming "a view of business as an engine of societal progress" (Schaltegger et al., 2016), as underscored by Massa et al (2017) it means that "societal contributions of companies are not limited to paying taxes, creating employment, or devising useful products (all of which fall within the paradigm of neoclassical economic theory and related lines of inquiry)" (p.96) and have a larger notion of value ie. not only economic as well as offer a multistakeholder and more systemic perspective than the firm-centred usually associated with the business model. Following those authors, "sustainability may revolve around challenging some of the assumptions behind the more classical discussions of business model" (Ibid.).

1.2.2. Business model innovation: toward deep sustainability

Other strategic approaches to innovation have integrated elements related to sustainability. For example, Orlowski, Evangelos Markopoulos (Ahram et al., 2020), following the concept of Blue Ocean (Kim & Mauborgne, (2004), propose the term green oceans to characterise the development of 'green market' they however remain silent about the doing of sustainability.

The business model concept has the potential to foster sustainability (Massa & Tucci, 2014), and it is essential to develop businesses 'or organisational forms' that internalise new constraints such as those related to ecological transitions, as such business model innovation is considered as key (Massa & Tucci, 2014; Warnier et al., 2018).

Despite the existence of literature on sustainable BMs, the business model framework does not integrate the notion of sustainability (Upward & Jones, 2016). Like the seminal BM literature, the sustainable BM approach is case-based, taking examples of established firms (Federico et al., 2020; Sosna et al., 2010) that transform their BM at the margin under institutional pressures. Bringing the concept of the Business model further to deep sustainability thus implies innovation in terms of BM.

The Business Model Innovation (BMI) is a literature at the intersection of innovation management and the Business Model literature. Massa and Tucci's (2014) definition of Business model innovation (BMI) is two-fold it can refer both to the design of novel BMs for novel organisations (ie.: Business Model Design - BMD) and also be intended as the reconfiguration of existing BM (Business Model Reconfiguration - BMR). In this paper, we may stick to the first meaning.

On the same token, the intensity of BMI is classified into four types: Regular, Position Building, Capability Building and Revolutionary (Afuah, 2014). Regular BMI aims at developing BMI that does not render other products obsolete, Position Building BMI refers to

the use of the existing capability to create an offer that renders obsolete products existing in the market, Capability Building refers to the development of new capabilities that do not jeopardise existing product from the old BM, the product can co-inhabit the market. Last, the Revolutionary BMI requires the development of new capabilities and products associated with rendering the old BM obsolete.

The literature shows how difficult it is for the concept of sustainable business models to emerge (Laasch, 2018; Upward & Jones, 2016). While the business model concept is adaptable to all types of organisations (Yunus et al., 2010), Massa and Tucci (2014) underline that emerging technologies with ecological dimensions are subject to greater constraints than more traditional technologies, in addition to the usual constraints on business development.

While efforts to date have led to a better understanding of the components of a BM (Lecocq et al., 2006; Massa et al., 2017; Schaltegger et al., 2016) the links between the various components, and the mechanisms for producing and capturing value (Demil & Lecocq, 2010; Johnson, 2010; Osterwalder & Yves, 2011), as well as varied but complementary analytical frameworks (Demil & Lecocq, 2010; Verstraete et al., 2013), there is little research dealing with the processes involved in developing business models.

Relying on the concepts of Business Model Design (BMD) and on the revolutionary BMI intensity of BMI we intend to bring the BM concept further to sustainability. The revolution BMI intensity sticks to the idea of integrating Living technologies into the models of innovation development that are so far based on Zombie technology. Integrating living technologies implies thinking differently about the products/services as well as the relations with the stakeholders and its organisational structure: designing a new Business model to fit Living Technologies properties.

2. A BIOCONTROL DEEPTECH ENTREPRENEURSHIP PROJECT: THE CASE OF SPEEDCONTROL

The weight of agriculture in climate and environmental crisis is well identified and measured (Intergovernmental Panel on Climate Change, 2023) and the use of pesticides is seen as a negative common (Bonnet et al., 2021) in the sense that it has an impact on the long term and must be taken care of by communities.

The agricultural field is a relevant example of the negative effect of technological development. Modernisation has been made by technological progress (Bonneuil & Fressoz, 2013; Cornu & Valceschini, 2018; Lamine, 2017). Even if this "modern" agriculture permits us to feed billions of people, we currently face the consequences of the industrialization of agriculture based on successive innovative revolutions since the introduction of hybrid seeds to edited plants and of course the green revolution based on chemical pesticides.

Public policy can act in different time frames both to eradicate pesticides and transform farming activities for the future. The European Union in its "Farm to Fork" strategy (European Commission, 2019) has the ambition to develop sustainable food production, however, it is still indicated "that digital is key to success" (European Commission 2022 p. 6) for the optimization of pesticide use with IoT. If those solutions require to be explored, they originate from non-renewable resources and have minimum durability in working order and a maximum life span as waste, as such they can be classified as Zombie technology.

In agriculture, the problems caused by technical progress are solved by other technical progress for whose potential risks are not balanced to their benefit. This is in line with the positive bias that imbues innovations. Farming 4.0 aims to solve the problems created by intensive farming, by intensifying the technological contribution of agriculture without taking

into consideration impacts of developing more digital devices, and the impact of their sourcing, use and discarding in terms of planetary limits. It confines to a vicious circle.

To achieve farming at a level that offers sufficient food resources, pesticides can be optimised through farming 4.0 solutions, but other biobased solutions that can lead to pesticide suppression also exist. Université Côte d'Azur with INRAE has a long-standing history in biological control[2] (hereafter biocontrol) research and development for farming with its research centre Institut Sophia Agrobiotech (ISA). Biocontrol implies the use of different kinds of biological entities to help farmers in their growing activities. It can be microorganisms such as bacteria or microorganisms such as insects but also natural chemical compounds such as pheromones (Jacquet et al., 2022).

Biocontrol encompasses 4 different strategies to fight against pests that range from the more usual practices which farmers are used to, to strategies that imply natural equilibrium in the long run. Those different strategies are Conservation biocontrol, Classical Biocontrol, Inoculation biocontrol and Inundation (also augmentative) biocontrol.

Inundation biocontrol implies repeated use each year, and it fits very well with current practices; all the other strategies are far removed from current farming practices. Developing biocontrol and techniques constitute viable solutions to agroecological transition, and opportunities to develop DeepTech innovations. Boutet and Parmentier-Cajaiba (2022) showed that the very properties of each class of biocontrol call for adapted business models (p. 228-229).

[2] 'The use of Living organisms to suppress the population density or impact of a specific pest organism, making it less abundant or less damaging than it would otherwise be' (Eilenberg, Hajek and Lomer, 2001)

It means that to develop the full potential of the different forms of biocontrol, society needs to think outside of the current farming practice box; and innovate to develop and diffuse those innovations that can, in the long run, be consistent with calls for sustainability.

2.1. Methodological approach

This research is the result of a Master 2 internship in a DeepTech research project team. The objective of the internships was to provide support for the strategic aspects for researchers in DeepTech to become entrepreneurs. This internship is part of a collaborative research (Shani et al., 2008) between the project leader, a postdoctoral fellow at INRAE, and author 2 who is part of the scientific council and follows the venture project.

The research method follows the dialogical model (Avenier & Parmentier-Cajaiba, 2012; Avenier, 2010). This methodological framework allows for the development of research questions that are relevant both for practice and academia because elaboration relies on both types of knowledge practitioner and academic and relies on relationality and interaction between the two parts. Taking into consideration varieties of knowledge echoes the principle held in the pragmatist inquiry principle that values diversity of knowledge and practices with equal importance reference.

Author 1 spent eight months with the project holders and had a mission to be held within the project team. As such he participated also in the inquiry led by the project holders to find their way out in their new environment: the start-up ecosystem. As such he experimented with them by following and participating in the elaboration of new goals and means, those related to the strategic content. In this sense, this methodological design fits with the pragmatist notion of inquiry (Bidet, 2008; Dewey et al., 2011; Kjellberg & Mallard, 2013)

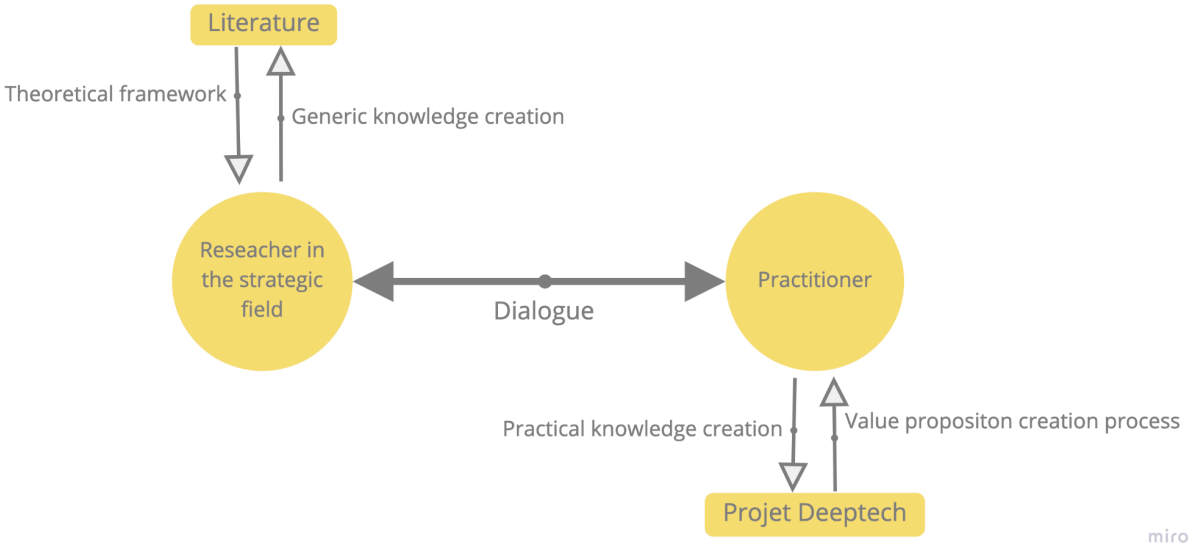

Figure 1: Dialogical model of the collaboration with the project.

We rely on the case of SPEEDCONTROL, a biocontrol start-up project integrated into the DeepTech support ecosystem in the southeast of France. This project proposes a biocontrol technology to optimise the use of macro-organisms for the control of crops. We focus on how the research-entrepreneur manages at the same time technical improvements of its technologies and the development of strategic thinking to propose a business model that fits the requirements of the entrepreneurial support ecosystem.

The collaborative research was organised to follow the process of SPEEDCONTROL value proposition elaboration, to identify the different steps implemented and to characterise the structuring events inducing inflexions in its construction.

2.2. Data collection

The Author 1 was inside the organisation and had interactions (Figure 2) (i) with the Research Entrepreneur to support value proposition construction for valorise the technology developed

by SPEEDCONTROL, (ii) with the Autor 2 to document the entire process of reflection on the construction of SPEEDCONTROL's value proposition. The authors kept track of the whole reflection process developed with modelling and strategic reflection tools.

We opened a collaborative and visual software to ordering ideas and evolution of the value proposition called “Miro”. Miro is a whiteboard, to create diagrams and mind maps. It's a highly visual tool for creating projects, it encourages collective intelligence. SPEEDCONTROL used it during meetings for brainstorming and ecosystem mapping. We keep all the processes of reflections of the value proposition and the evolution.

We also have at our disposal all the necessary materials for pitches, calls for projects and their inflexions on Google Drive.

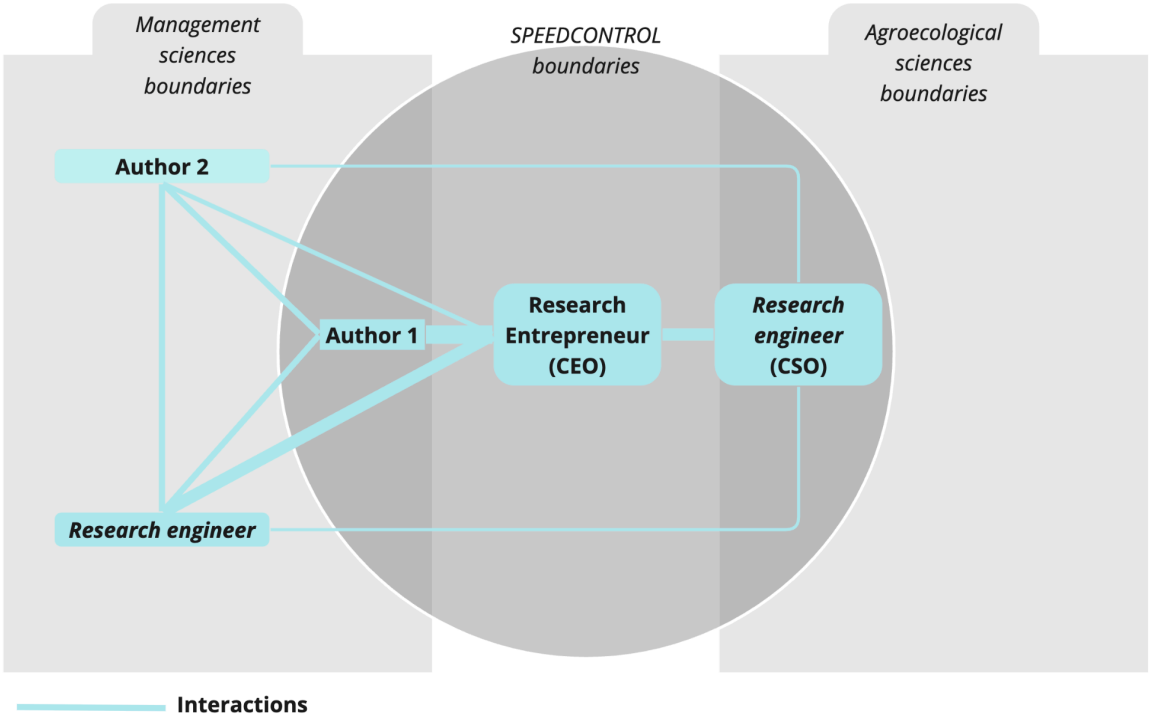

Figure 2: Interactions during the internship

We collected all the meeting points on a collaborative agenda on a software called “Notion”. We distinguish 6 types of interactions and meeting sessions (Table 2).

Types of Meeting	Detail	Number of meeting
Work session with the entrepreneur researcher	Dialogue between Authors and the CEO of Speedcontrol	31
Entrepreneurship training	Training sessions and course form : • Deeptech Entrepreneuship Diploma • Workshop, Bootcamps and Summer/Winter school about deeptech entrepreneurship	29
Work session with the entrepreneurial ecosystem	Meeting with the Incubateur Provence Côte d'Azur or Inrae transfert, Bpifrance, Région Sud	32
Worksessions for financial aspect	Work session to raise public/private funds	15
Networking	Dialogue with other entrepreneurs durings afterworks	13
Market Study	Market studys préparation with skema conseil : (4) Interview (42)	46

Table 2: Meeting types during the internship

Using these empirical materials seems relevant for observing the development of a Living Technology in the agricultural field, which is shaped and reshaped in an entrepreneurial environment. This allows us (i) to characterise and identify the components of Living technology, (ii) to observe its confrontation and evolution concerning its value network, and (iii) to perceive the levers for developing Living technology.

2.3. Analysis

We identified turning points that structure the evolution of the value proposition. Those turning points reflect the changes in the value proposition under the observation of entrepreneurship and market stakeholders (Figure 3). We further analysed the discourses to identify elements engaging entrepreneurs to modify their value proposition. We focus on the quality attributed to the resources engaged in DeepTech innovation in biocontrol.

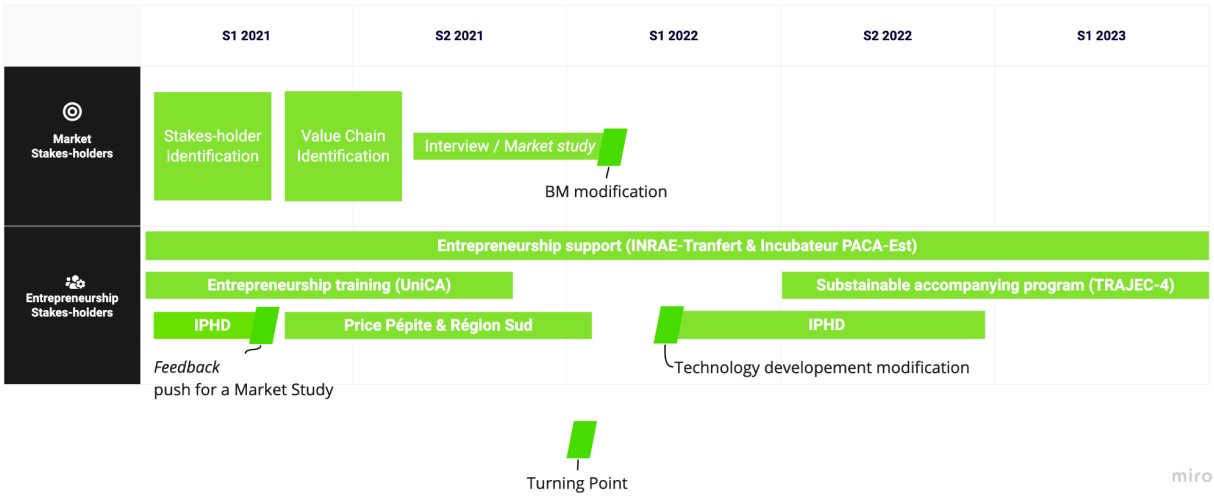

Figure 3: Phases of elaboration of the value proposition and turning points.

2.3.1. Dialogue with the entrepreneurship support stakeholder

The creation of the DeepTech Start-up was linked to the entrepreneurship support ecosystem. This ecosystem enables project leaders to secure financing for the development of the technology, typically through calls-for-projects.

The support ecosystems create constraints that are sometimes not consistent with the technology itself. One can notice that the entrepreneurship support process is valuable because it provides a frame to act, a vocabulary and introduces market logic to researcher-entrepreneurs. We also observe that the goodwill of entrepreneurs to implement the tools and models proposed impact how the entrepreneur is perceived by the ecosystem. The more tools are used, the smoother relationships are with the ecosystem.

We interpret this phenomenon as a trust-generative mechanism. Abiding by the process proposed by the support ecosystem is indeed a way to assess both the motivation and the relevance of the project leader.

To assure the development of the Living technology, SPEEDCONTROL needs the approbation of this ecosystem, and we observed this truth generator process is based on feedback given.

In January 2021, the project leader lost the first call for projects (IPHD). This loss generated two major feedback: (i) the need for the SPEEDCONTROL team to integrate business skills,(ii) the need for the Researcher Entrepreneur to “emphasise the need of the market” and conduct a Market Study.

The project team was constituted at first of researchers specialised in the biology of interaction Marina developed the technology during her PhD supervised by Nathan his former PhD Director the second member of the team. Marina was asked to develop her business skills and followed the “DeepTech entrepreneurship diploma”. However, it has not been taken into consideration and judged insufficiently, they were asked to associate a co-founder with business skills to the start-up project through the "TANDEM" program.

The Start-up project was also enjoined to conduct a market study using specific tools, and to achieve a market study whereas the level of development of the technology was still at the concept-proof stage. The project team was obliged to perform this market study at a very early moment of the development to fit the entrepreneurship support roadmap. We delve into this in the next section.

2.3.2. Insights biocontrol market stakeholders

To realise the market study, we first try to identify extensively the potential stakeholders of the biocontrol market that could contribute to the value chain of SPEEDCONTROL.

We then listed a group of 135 actors to identify their stakes, needs, and problems related to the use of insects in the agricultural field. We attempted to categorise their roles from the

perspective of the value chain to analyse the different perceptions of the Living technology and to prioritise the development of components of this technology. We chose to interview 42 actors based on their potential position in the value chain (Figure 4).

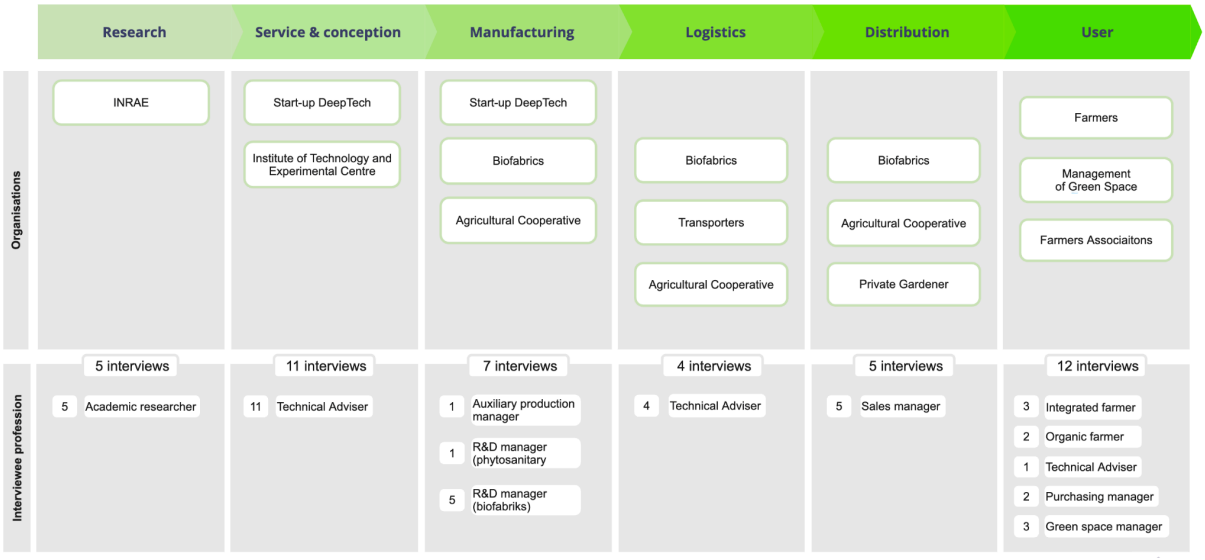

Figure 4: Potential Value Chain for SPEEDCONTROL

- **Actors in the research area:**

The main player in this field of research is INRAE, an institute that works in collaboration with other actors to develop new solutions to combat pests. Researchers working on the development of beneficial insects see the potential of this resource.

"This [beneficial insect] is found in many different crops so it is present. There are real possibilities to find solutions knowing that [beneficial insect] is easily raised, that it is an insect that is interesting because it attacks before the damage, it is essential to develop it because there is a real demand." *Research Engineer at INRAE.*

However, their researchers point out a lack of research investment to develop this Living technology and more generally biocontrol techniques.

"The lack of funding is a very recurrent problem, and it is a major issue in the implementation of biological control." *Research Engineer INRAE.*

This lack of investment is present in the literature, "The problems spontaneously expressed by the actors developing products - the lack of financial support for R&D on the one hand (which have led, for example, to a demand for an increase in the research tax credit for research and development on biocontrol)" (Jacquet, Florence, et al. 2022, p.126).

- **Actors in the conception area**

Agroecology Deeptech start-ups are designing new products and services in cooperation with technical institutes that support the experimentation of new solutions. According to them, the use of beneficial insects (Living Technologie) has limitations in terms of effectiveness, productivity, and profitability in regards to the standards (Zombie Technologie) required by players in the domain.

"Ideally, there should be biocontrol adapted to each problem. The use of all these biocontrol products requires time and additional cost in addition to the cost of the product. All this is part of the barrier to implementation." *Research and Development Manager of an Institute of Horticultural Technology.*

"Working in research and development, when I have 50-60% effectiveness with crop helpers, I'm satisfied because it works. This is not necessarily the case for a farmer who is used to 90% efficiency with chemical products," *Research and Development Manager of a French Interprofessional Association of Conserved Vegetables.*

What is striking is that in the current context, even people working in and for the domain of biocontrol do value better pesticide efficiency and value negatively the efficiency of their products. Conventional agriculture is the main reference framework and thinking outside of this box is a real challenge.

- **Actors in the production area**

Companies such as biofabrics and agricultural cooperatives produce insect-based solutions to combat pests. For these producers thinking about the marketing and application of products is important. They are used to the practices of chemical inputs.

"It [beneficial insect] should not be too capricious. The beneficial insect must have the ability to settle under cultural and climatic conditions that are not too reduced," *Manager of beneficial insect breeding of a Farming Cooperative*.

"It would be an easy-to-use solution for producers. You bring the insects once in the culture and then it works on its own." *R&D Engineer of a DeepTech project.*

Products can be sold as a mite product rather than under their scientific name to facilitate their use.

"Sometimes a good insect-based product can be poorly presented, it's a question of marketing and communication." *Production Manager of a French Biofabric*

At this level of the chain, it is the practices of application and marketing that are called to mimic those of chemical pesticides.

- **Actors in the logistic & distribution area**

Companies such as biofabrics and agricultural cooperatives will transport the insect-based solutions.

"Production is the first link but it is not the most annoying. After that, there is the whole logistics and commercialisation phase, which implies additional costs to maintain the survival of the helpers during transportation [...]. So why buy microorganisms." *Operations Manager of an Italian Biofabric.*

Agricultural cooperatives can distribute biocontrol solutions to farmers, but they are limited by regulation, particularly the approval of these solutions which must prove their effectiveness. This can result in delays and additional costs.

"[due to regulation] it's easier to accept a chemical product, that's all." *Operations Manager of an Italian Biofabric.*

"[because of the cost of the regulation] Many laboratories or start-ups avoid all this, develop solutions of type fertilising material, or culture support. We no longer claim biocide support. We can only claim a bio-stimulating use so we are a bit in the fog on these developments. Better a phytosanitary approval" *Director of a Wine Technical Institute.*

It appears that the potential stakeholders tend to either avoid the use of biocontrol because of, the difficulty of transportation, the lack of clarity of the regulation; The negative assessment of biocontrol is partly due to the intrinsic quality of biocontrol (Transporting Living things) and to the extrinsic aspect: a regulation that appears risky. It ends in pushing the use of pesticides even though the withdrawal of pesticides increases each year.

- **Actors in the end-user area**

"The idea would be to create a range of solutions, and the farmer would only have to compose the menu most adapted to his situation. Make sure that farmers do not have to give up a crop because they are not able to manage it." *Research and Development Manager of a Wheat Technical Institute.*

This verbatim shows that farmers are takers of solutions and that conventional agriculture does not value their knowledge. Using biocontrol implies reinvesting in technical knowledge, to assess their fields and productions. As Lamine (2017) underlines, there is also a sociocultural risk related to the change in practice, particularly in terms of injunction in certain sectors to maintain the "cleanliness" of the farm plot. It is always perceived as a constraint and not as a potential reinvestigation of knowledge for farming producers.

3. KEY INSIGHTS

3.1. Support process scalability and anthropocene

Initially, the start-up envisioned selling its technology by targeting contract services to users of auxiliary insects in crops. Based on our analysis of the various segments of the value chain, we concluded our collaboration that the technology was well-suited for the upstream portion of the value chain and holds potential for service provision to firms engaged in the production of biocontrol solutions.

However, because this mode of commercialization was deemed non-scalable by the support environment, it prompted the start-up to reassess its strategy. The firm has to propose a product the start-up proposed the production of mini-autonomous stations that manufacture insects. This shift is aligned with the state's vision to re-industrialize France, particularly in Agritech, by promoting the emergence of biofabric projects; but does not fit the particularity of biocontrol technologies and its organic (ie. Living) nature they require a different care than that of chemical nature.

The argument put forward to push this transformation is the search for a scalable business. We interpret this as an adaptation of support models from digital technologies (Zombie Technology), which have been particularly popular for the last twenty years. The idea of scalability is associated with the number of users more than the number of uses, which disqualifies an approach in terms of servicization in this particular network.

Since the BM concept emerged from digital business, we argue that the training of support entertainment is mainly based on the use of strategic tools. Those tools are used sequentially. This sequential use of stratégic tools put the Team project under pressure and generated a gap between the expected capacity of the technology and the real capacity of the technology.

By using the framework of the development of Digital technologies, The support environment judges the scalability of a Living technology before the realisation of its proof of concept. They don't take into account the complexity of the early stage of Living technologies.

In light of these observations, we note a premature eagerness within the entrepreneurial ecosystem to scale. We align our observation with Bonnet et al. (2021) in relanding technologies related to territorial supply chains and redesigning them accordingly. We observe that the time scale of DeepTech innovation does not align with that of biocontrol and biotech innovation. Even the entrepreneurship support ecosystem acknowledges that they had to "play by the rules" to support such projects.

However, scalability in the agricultural field leads to intensive use of resources through the proliferation of devices, which may be incompatible with the simplicity and resource limitations necessary to adapt to the Anthropocene.

The entrepreneurial ecosystem does not thoroughly assess the appropriateness of the technologies. We observe that more than the appropriateness of the technology, the evaluation of Deeptech projects is based on the ability of the project team to demonstrate scalability potential, which is contradicted in the current agricultural context. We associate this with the innovation bias of "introduction-of-something" (Godin & Vinck, 2017).

3.2. Living/Zombie Technologies in competition

The market study has highlighted a negative perception of macro-organisms as a tool for combating crop pests among agricultural economic actors.

Stakeholders do not evaluate biocontrol negatively for the same reasons (Figure 5), but they do compare it to chemical pesticides, which is the global reflective framework, yet it is a

Living technology. However, in the context of the Anthropocene, we can no longer rely on Zombie technologies.

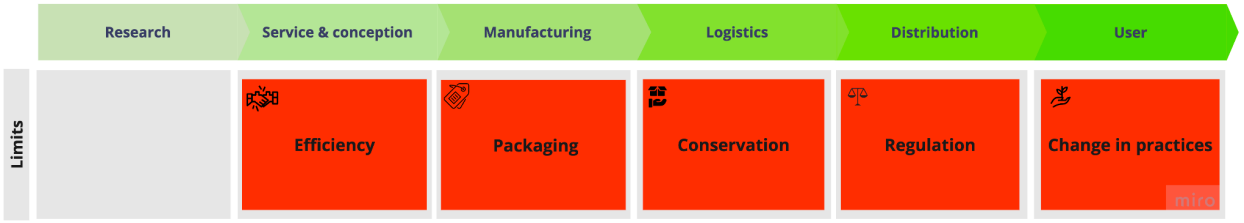

Figure 5: Value chain of SPEEDCONTROL, actors and limits

Conventional agriculture has developed over the last 60 years, favouring the use of chemical pesticides and fertilisers. Consequently, they are considered the standard solution for protecting crops.

This has led to a negative perception of macro-organisms as a biocontrol tool, as they are not perceived as being as effective as pesticides in combating pests. Because the use of biocontrol is an integral part of integrated pest management, it also implies rethinking food production on several aspects, including its value chain, production models, and modifications of technical itineraries. These changes pose barriers to the evaluation of insects as a strategic resource for agricultural actors. This involves the combined use of different biocontrol techniques to preserve both agricultural production and its ecosystem.

3.3. Living technologies perspective of development

Highlighting (i) the injunctions of the entrepreneurship ecosystem to scale and (ii) the difficulty in going beyond Zombie technologies paradigms from market actors. We observe that developing Living technologies implies taking into consideration interactions between humans and nonhumans more than with Zombie technologies. We also want to highlight the levers that would allow the development of Living technologies.

The underinvestment in developmental research, particularly the use of macro-organisms, leads farmers and actors in the value chain to fear the withdrawal of pesticides because of no orientation on (i) how to change uses and (ii) how to transform the activity in line with the properties of that new technique. The low level of revenue of farming actors is also a constraint to trying new solutions in development.

The development of these resources through DeepTech is a glaring example. A DeepTech project developing a Living technology and using resources must prove its potential. We demonstrated that despite the perceived limitations of the value chain actors, Insect-based technologies still need to overcome many technological and commercial barriers related to the use of those new Living techniques.

From a strategic perspective, the legal framework constitutes a constraint to the technique development in the case of microorganisms. The legal framework was developed by and for chemical pesticides, and micro-organisms associated with bio-pesticides were integrated into this costly and complex procedure of registration. In the case of insects, the uncertainties linked to the legal framework, their transport and a whole set of measures contribute to the negative valuation of the Living Technology. So far, the supply chain has not yet adapted to this Living technique which makes another gap to cross for users.

The strategy of biofabrics to market macroorganism strains will be to package them in solutions that resemble synthetic products as much as possible. The use of biocontrol, particularly insects, results in changes to agricultural practices and modifies the technical process. This requires a return to forgotten practices, this modification (Lamine, 2017) could be supported with other organising activities, like training and could generate other businesses to disseminate this kind of Living technology.

4. DISCUSSION AND CONCLUSION

We concur with Crutzen and Stoermer (2000) that the beginning of the anthropocene is linked to the notion of technical development and innovation. Since Schumpeter (Aggeri, 2023) innovation has been mainly intended, as a factor that fosters economic growth and provides solutions to technical problems, and the term innovation is glowed with positivity (Vinck, 2017) and barely criticised. However, successive IPCC & IPBES reports as well as the work of the Scandinavian Resilience Centre confirm that the rhythm of natural resources and biodiversity depletions are concomitant with the successive emergence of technologies that accrued since the 1st industrial revolution. As such, we inherited the notion of innovation as a positive term, and we argue that its consequences on the earth system hence on humanity have not been taken seriously so far.

DeepTech projects and innovations have the potential to provide solutions to environmental and climate problems (Nedayvoda et al, 2020) however controversies are emerging related to the sourcing of resources needed to develop, implement, and market those innovations. and we bring the concept of Zombie and Living technology with the idea that it can bring about a way to differentiate innovation on its ability to not impact or maybe contribute to restore planetary limits.

We investigated the opportunities for promoting the adoption of sustainable technology in the market by identifying key themes and areas for future research and development. The case study allows us to follow the interests of different actors in a value chain toward a Living alternative to an established technology. This case study provides insight into the potential to integrate Living technology into the system and promote their use.

4.1. Living technologies: a promising concept

We show that Living technologies are consistently compared by actors in the existing value chain whose activities are based on Zombie technology. Even for actors involved in the development of this technology, their creativity is constrained by the framework imposed by Zombie technologies.

The concept of Zombie/Living technology is in its early stages and Landivar (2021) mentions a perspective of dis-zombification of technologies. We propose that contemplating the development of technologies through this concept could illuminate practices and enable practitioners to distinguish technologies and engage in a process of *desincubation* for Zombie technologies. Because, Zombie technologies are well-defined, and examples are characterised.

But Living technologies are more challenging to exemplify because little is in use currently. We also show that through the entrepreneurial process, technologies that could be classified as Living technologies risk being zombified. Indeed, the cognitive framework of counsellors is imbued with habits and practices developed about Zombie technologies. As such we refine the Zombie technology concept by showing that Living technologies are not sufficient by themselves. Their embeddedness into the socio-technical system as well as associated habits must be taken into consideration for their diffusion.

4.2. A framework to disengage Zombie Technologies

The entrepreneurial ecosystem with its call-for-project financing system pushes DeepTech into a fixed time range and expects scalability at a generic moment. This scalability leads projects with Living technologies to the reproduction of Zombie technology commercialization models. This commercialization model can result in overusing resources and thus neutralising the environmental benefits of their technology and creating a zombification of Living Technologies.

We showed that the Business model Concept can have many forms of possibilities to integrate the complexity of sustainability value (Massa et al., 2017; Massa & Tucci, 2014). in opposition to Bonnet (2021) idea of negative commons, we show that when used as a cognitive heuristic the Business Model Concept can also be a lever to keep dialogues between Science and Practitioners, as such it can be a tool to foster inquiries toward the integration of Living technologies at all the level of the value chain of an organisation.

Through the dialogical model, researchers in the field of management can positively influence the way practitioners use the concept in light of the Anthropocene. A better understanding of how technology entrepreneurs construct and position their value propositions, build their entrepreneurial projects from their research, and manage interactions with their support environment offers potential for theorising processes of sustainable business model construction since we know very little so far on the processes of BM innovation elaboration.

4.3. Limits and perspective of the case study

Our article is based on only one case of agroecology DeepTech start-up project, this longitudinal analysis is realised in the south-east of France and should be compared with other cases. The interviews were realised for a market study to understand the perspectives of stakeholders in the value chain. We intend to run a co-occurrence analysis to better understand the relations to the biocontrol of actors.

The example in farming shows that DeepTech has the potential to advance ecological transformation in farming but must meet a threefold challenge: (i) Finding ways to integrate Living technologies. (ii) Thinking about it at different time frames to achieve a transition inside the planetary limits that remains socially acceptable, (iii) accepting that it is not only a question of product substitution but of changing our way of Living by integrating the use of differently valued resources.

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