Theories for innovation analysis

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1   PU = Public
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Summary

Deliverable 1.5 "Theories for innovation analysis" is based on task 1.4 "Theories and methods for transformative biodiversity innovation analysis". It aims at providing a consistent platform of theories as well as empirical examples that could potentially inspire the field research in BIOTraCes Project, laying the basis for elaborating a brand-new theory on transformative change.

The literature review and list of theories and approaches mentioned in this report are the result from a discussion with partners that took place in two dedicated project meetings. Then, each research team was called upon to fill out a form, providing its own idea about the notion of "innovation" and emphasizing which meanings and conceptualisations or counter-conceptualizations could be applied to the field of transformative change theory to analyse and support biodiversity repair or restoration. The different teams were asked not only to suggest theoretical frames useful for critically approaching the concept of innovation, but also to add a list of existing case studies that could exemplify the link between theories and methods, and the challenges posed to research and practice when biodiversity innovation is at stake.

As task leader, the UNICT team was responsible for collecting the various contributions coming from each research group, trying to build an index and an analytical structure for this deliverable. Then, the report was commented and validated by all partners who collaborated in drafting the final document.

This text is structured as follows: in the next section we will analyse the genealogy of the concept of innovation and the plurality of conceptualizations to which the concept refers, especially in its environmental dimension or when it is specifically related to biodiversity. Subsequently, we will offer an overview of several theoretical approaches used to study innovation, highlighting their potentialities and limitations for the study of biodiversity transformative change. Finally, a list of case studies will be examined that fall within the four BIOTraCes sectors/domains - (a) Maritime/aquatic living sources; (b) Forestry; (c) Agriculture and food production/consumption (d) Urbanization - to highlight the connection between theory and applied methods as well as between innovation practices and policy implementation.

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Summary

1 Innovation theories and their relation with biodiversity and sustainability

1.1 The genealogy of the "innovation" concept

The concept of innovation is extremely complex and difficult to reduce to a single defining paradigm.

Early reflection on innovation emerged in the early modern period when, after the invention of the printing press, people started exchanging concepts and ideas through books (Godin 2008). However, etymologically some dictionaries indicate that the words "innovation" or "to innovate" have come in use since the sixteenth century: The French word innovation dates to 1559, the English word innovation to 1540, the old Dutch word *innovacie* to 1503.

Ufer and Hausstein (2022) deconstruct and reconstruct meanings commonly associated with the notion of innovation, including both cultural innovation and social innovation, from the perspective of anthropological theory. Before 1900, the term in anthropology had no clear semantic difference from similar terms such as "invention", "novelty", or "change". Because the term innovation came to refer to new methods and products in scientific and technological development, innovation became promoted for its "sound grounding in scientific principles" (Godin 2016: 536, in Ufer and Hausstein 2022). This means also relating the term to "the acts of individual innovators and setting the path for innovation to become a key concept in modernist and progressivist discourses" (Ufer and Hausstein 2022). This tendency partially explains the reluctance of anthropology to fully incorporate the notion: "It is not at all surprising that the semantic content of innovation as an emerging key term for the self-definition of Western modernity, individualism, technological progress, industrialization and capitalist market society simply did not match early anthropology's epistemological aims and was largely incompatible with its emerging vocabulary" (ibidem).

In pre-modern times terms such as "invention" or "progress" fulfilled the same semantic function as modern-day notion of "innovation" (Haller 2014). In Nineteenth and Early-Twenty century, for instance, with evolutionary sociology, there was a "conception of change that is fundamentally different from the present-day semantic content of innovation" (ibidem). Spencer, for instance, "located the evolutionary driving force for change clearly outside human agency, consideration, intentionality, or wilful planning" (ibidem). In line with this consideration, Ufer and Hausstein stress how Spencer "ultimately perceived the self-acclaimed managers of change in politics and industry as 'political schemers' whose clumsy attempts at social engineering were, presumptuous, plainly unnecessary and in the worst case harmful to the natural evolutionary tendency towards perfection, the 'mighty movement – towards a complete development and a more unmixed good'" (Spencer 1851: 293). As also Godin (2014) suggests, more fine-grained attention needs to be paid to the semantic content and discursive functions the term innovation plays in different times and places. With a view to present-day discourses and politics of innovation, this analysis of the pitfalls of retrospective labelling might be extended to a critical questioning of the term innovation in the current hodge-podge of "X-innovations" (Gaglio, Godin and Pfotenhauer 2017).

In this sense, many scholars have highlighted how a crucial evolution of the concept of innovation started to be the object of a compartmentalization (nature/society) that has been discursively and historically constructed. Kaika (2005: 5), for instance, identifies in

the historical geographical process that started with industrialization and urbanization the moment when this separation was discursively operated. This has led to innovation being thematized more and more in terms of technological or economic innovation, tending less and less to take into consideration the dimension of the environment and more-than-human worlds.

Moreover, the concepts of innovation as well as those of transition, and transformation do not have clear definitions and boundaries in the literature. Transformation is often defined as deep change that addresses the underlying causes of multiple social and environmental problems, including growing inequality, biodiversity loss, and climate change, and that is inherently political because it threatens dominant interests and power relations (Stirling 2015; Bluwstein 2021; Pelenc et al. 2019; Visseren et al. 2021; Turnhout et al. 2021). The concept of transition above all refers to a systemic and structural change that is built over the long term and emanates from top-down actions, for example from laws and precise political and institutional structures. The concept of transition also refers to a gradual, dynamic and assisted and strongly policy-oriented vision of the transformation process. Such an idea is also fundamentally anchored to a technocratic faith in the growth and capitalist paradigm, which hides paradoxes and limits of transitional process in terms of social conflicts and inequalities (Lowe 2015; Sato 2017). Even the idea of innovations for green transitions have been criticized for failing to consider these political and power dimensions, and for taking narrow technocratic or siloed and sectoral approaches that fail to address the underlying causes of problems (Kenis et al. 2016; Pelenc et al. 2019; Ludwig et al. 2021; Heberl et al. 2019; Van den Berg et al. 2022; Schlosberg and Coles 2016).

In a book titled *Understanding Innovation Through Exaptation*, La Porta, Zapperi and Pilotti (2020) explore the role of "exaptation" in diverse areas of life, with examples ranging from biology to economics, social sciences, and architecture. This notion was introduced in evolutionary biology by Gould and Vrba in 1982 to describe the possibility that "already existing traits can be exploited for new purposes throughout the evolutionary process" (ibidem). The notion has been at the centre of heated debates for more than 20 years. The authors in this edited book illustrate the importance of exaptation for interpreting current reality in various fields of investigation and comprising many disciplines in an attempt of integrating them in a holistic approach. For instance, there is a chapter where Antonio Mastrogiorgio and Mariano Mastrogiorgio (2020) explain the role of "affordance landscapes" in exaptive innovations, emphasizing the "ability of living beings to prefigure landscapes of potential affordances in order to reach specific goals" (ibidem). Interesting is also the idea that exaptation could help researchers to develop a theory that builds on two kinds of self-organization structures in the world: "The first is living organisms. The second is complex minds, or more precisely, worldviews: ways of seeing the world and being in the world" (Gabora and Ganesh 2020). Here we see the extent to which biological sciences and social sciences are trying to reconnect their heuristic mission today. Indeed, the effort of modifying/changing a cultural or biological pattern (also a pattern of cognition) to incorporate different perspectives, thereby increasing cultural/biological variation, is presented by the authors as something connected with how living beings view "not only the world around them, but also their own place within it" (ibidem).

Going back to the notion of "affordance" - in the sense of possibilities for action provided to animals, including humans, by the environment they live in (Gibson 1979), a big step forwards, in reconnecting biological and cultural reasonings in a more unified perspective, thus transcending the nature-culture dichotomy, comes from "niche construction" theory (the theory that explains the process by which living organisms modify their selective environments). The landscape of affordances we inhabit as humans and more-than-human

assemblages "is very rich", as Rietveld and Kiverstein (2014) state. This notion, thus, has a much broader application than has hitherto been supposed, especially when analysing innovations connected to transformative socio-ecological change. Rietveld and Kiverstein argue that "the affordances the environment offers are dependent on the abilities available in a particular ecological niche" (ibidem). However, they also add that "the relation between the affordances and the adequate exercise of abilities in a context" is embedded in "forms of life", in Wikteinstain's human/cultural terms. "The flexibility that the notion of a 'form of life' offers - they write - allows us to capture the variety of practices within the human way of life" (ibidem). Tim Ingold comes toin similar conclusions. He describes skill and skill acquisition processes that applies equally to both humans and nonhuman animals:

"The abilities of the weaverbird, just like those of the human maker of string bags, are developed through an active exploration of the possibilities afforded by the environment, in the choice of materials and structural supports, and of bodily capacities of movement, posture, and prehension. Furthermore, the key to successful nest building lies not so much in the movements themselves as in the bird's ability to adjust its movements with exquisite precision in relation to the evolving form of its construction" (Ingold 2011, p. 358; Ingold 2013), as embedded in a particular form of life.

1.2 Varieties of innovation: Comparing concepts and their relation to nature and biodiversity

The prism of definitions of innovation potentially linked to the topic of biodiversity is so rich and multi-faceted that it cannot be presented here exhaustively. Innovation concepts may be mutually exclusive or closely interrelated. Schools and traditions of thought animating academic debates on innovation and its role as a positive driver for biodiversity are not only diverse, but often at variance with one another. A complete mapping of their positions and relationships is therefore beyond the scope of this report.

To give an example of this variety and heterogeneity, Carr et al. (2016), as well as Caldwell and Millen (2010) theorize that innovation enables individuals to better adapt to and respond to changing environments, improving current behaviour and facilitating humans in formulate more efficient solutions to problems. Other definitions instead remark how innovation influences the external environment in unpredictable ways: "Innovations are in a significant way new and disruptive towards the routines and prevailing structures" (Evers et al., 2014).

Taking these limits into account, what we present here is a synthetic mapping of the main notions of innovation that have opened up to an "environmental sensibility" when affording the processes of socio-economic and cultural change or that are in some way connected (even indirectly) with the topics of biodiversity and nature-positive society.

1.2.1 Animal innovation

According to Reader and Laland' (2003) view on animal innovation, there are two possible definitions of innovation: (a) An innovation "sensu product" as a new or modified learned behaviour not previously found in a population, and (b) an innovation "sensu process" that results in new or modified learned behaviour, thus introducing novel behavioural variants into a population's repertoire. The authors argue that "a strong case can be made for the assertions that many animals — not just humans — innovate, that innovation can be regarded as qualitatively distinct from related processes such as exploration and learning,

and that innovation is likely to play important roles in the lives and evolution of many animals" (ibidem).

Grant Ramsey, Meredith L Bastian and Carel van Schaik (2007), similarly remark that innovations may affect a species' ecology and evolution deeply. The authors define innovation as "the process that generates in an individual a novel learned behavior that is not simply a consequence of social learning or environmental induction" (ibidem), but something more complex and nuanced that should be studied in a systematic way.

Social learning in animals and culture and geographic variation in animal behaviour are a large field of study where anthropologists and ethno-biologists interact in a common effort of understanding where and when innovations "flourish".

1.2.2 Cultural innovation

George P. Murdock introduced the notion of "cultural innovation" as a specifically cumulative and therefore procedural and incremental process (Murdock 1932, 202). The term was then taken up in Homer G. Barnett's elaboration of an anthropological procedural theory of culture change involving a classification of different types of innovation (Barnett 1940, 1941, 1942b), and then again, a few years later by Albert Heinrich's (1950) notion of "acculturative innovation." Here, however, it is important to note the contrast between, on the one hand, procedural, or incremental notions of innovation as ongoing sociocultural practice, and, on the other hand, divergent conceptions in other disciplines such as economics. The specific research gap or problem that this anthropological framework aims to address refers to definitions of innovation as quintessentially revolutionary, radical and disruptive; definitions thus generally related to capitalist processes, as Schumpeter's notion of "creative destruction" (see Godin 2014a: 225). Indeed, in developing his notion of cumulative and procedural cultural innovation, Murdock argued against the dominant modernist individualistic conception that cultural innovations "full-fledged from the brains of their reputed inventors" (Murdock 1932: 206). Ogburn (1926: 227) criticized the "hero-worship" of inventors as well, emphasizing the social forces behind innovation, just as the anthropologist Murdock (193: 206) had done when he stated that an "innovation may spread or stagnate, (but) once launched into the stream of culture, it is beyond the power of any individual to control". In synthesis, Murdock came to understand cultural innovation as a long-term and complex process, depending on interrelations between human practices, their environment and our capacity to attribute meaning to the lived-in world.

In this regard, Carlsson (2007) pointed out that Schumpeter's emphasis on the individual entrepreneur led him to overlook the diverse origins of information input and the importance of a national innovation system. According to Carlsson, adopting a systems approach has three important outcomes: firstly, it requires a detailed specification of the system's constituent elements; secondly, it involves an analysis of the interrelationships among these components; and lastly, it entails a description of the attributes or characteristics of these elements. Eggink (2012; 2013) comes to similar conclusions when he underlines that an innovation system encompasses participants or actors, as well as their activities and interactions, within the socio-economic context in which they operate, collectively influencing the innovative performance of the system.

1.2.3 Retro-innovation

Another concept that is receiving growing attention in the debate around innovation is the notion of "retro-innovation" (Zagata et al. 2020). This refers to a purposeful revival of historic practices, ideas and/or technologies. The concept of retro-innovation is pivotal in contemporary discussion of rural development and agricultural transitions as generative processes of specific knowledge systems that are opposed to dominant agricultural practices. Stuiver (2006), for instance, defined retro-innovation as a "strategic niche management" (SNM). Anna Garre's study on farming with draft animals in small-scale farming in Northern Italy also makes use of the concept of retro-innovation connecting it to sustainable agrarian development (Garre 2022).

1.2.4 Niche innovation

In traditional business studies, niche innovations are innovations (generally technological innovations) that are "protected against too harsh selection and are provided with space to grow and mature through gradual experimentation" (Lopolito, Morone and Sisto 2011). According to a classical theoretical framework, niche innovations happen with the direct activation of people and tends to manifest in places where "problems of poverty, social exclusion, and inequality cannot be sufficiently addressed by local institutions" (ibidem). In such a context, niche innovations are seen as innovations carried and developed by "small networks of dedicated actors, often outsiders or fringe actors" (Geels and Schot, 2007). Their need to tackle social problems in innovative ways, and develop new concepts, instruments and services, however, might give way to an increasing emphasis on the importance of being "changemakers" as a self-proclaimed status more than a substantial feature. In addition, niche innovations may progress to become embedded as business as usual. This is why, there is a tendency to advance what is called "strategic niche management" (SNM) as a tool for understanding and managing "radical" socio-technical innovations and facilitate their diffusion (Witkamp, Raven and Royakkers 2011).

1.2.5 Process-oriented innovation

Process-oriented innovation is a concept that focuses on governance process that emphasizes the relationality between society and nature, creating positive relational (place-based) bonds between each member of society and through different facets of nature. Relational values centred around creating "socio-natural communities" build upon deeper connections, emotional bonds, place attachments, and multiple identities and sentiments of care and stewardship for both nature and society (Pascual et al. 2023). Relational values have been defined as "preferences, principles, and virtues associated with relationships, both interpersonal and as articulated by policies and social norms" (Chan et al. 2016). They refer to "values that do not directly emanate from nature but are derivative of our relationships with it and our responsibilities towards it" (Pascual et al. 2017). Relational values have been put forward as a conceptual bridge to overcome the strict dichotomy between traditionally formulated "intrinsic values", that refer to the inherent worth of nature, and "instrumental values", that reflect a one-directional, often utilitarian (and substitutable) relationship between nature and society. Although this dualism has informed enviromental thinking since the 19th century, nowadays nature conservation often implies the idea of protecting nature, as a universal value, for its own sake. Such an approach engenders contestations with local communities, which may have

different values and understandings of nature, rooted within place-based practices such as agriculture, fishing, hunting, gathering etc.

The idea of nature's rights is a way to implement a relational approach that recognises place-based values (e.g.: indigenous cultures and practices) as key to protecting nature. In doing so nature's rights aim to safeguard both local understandings and livelihood and the global need of protecting and enhancing biodiversity. Instrumental values expressed in markets are those values dominating today's political and economic decisions, as well as environmental policies. An overemphasis on instrumental values tends to reinforce hegemonic power relations and decision-making structures (including institutions understood as norms and rules), as they follow a mostly Western and utilitarian approach to think about society-nature relationships. The ecosystem services framework, for instance, draws from this tradition.

In reaction of this risk, process-oriented innovation theories propose to forge and deepen our understanding of forms of articulation of relational values by local groups and collectives as a possible frame to advance the idea of "place-based biodiversity innovations". These are forms of innovation that emphasize the situated and place-specific meanings of nature, and that explore why they matter to people, shaping social cohesion on the ground. Furthermore, relational innovation theories place a specific emphasis on "positive" relational values (e.g., care, place attachment, stewardship) nurturing desired forms of identities related to the way people live from, with, in, and as nature, as well as on relationships within social communities and between different social communities deriving from common lived experiences. A "successful" biodiversity innovation thus is associated with a transformative governance model that includes bottom-up and participatory decision-making processes (connecting a broad set of actors) and is based on shared values collectively promoting policies whose underlying narrative is pushing forward the idea of relationality. This idea also connects to the broader transition literature as it sheds light on the underlying worldviews, knowledge systems, values and power dynamics required for transformative action in ways of framing of the nature-society nexus that emphasize connectedness and "positive" relational bonds with nature and among people through nature.

1.2.6 Economic innovation

The concept most dominant in narratives on innovation in the nineteenth century is the concept of economic innovation. The Organisation for Economic Co-operation and Development (OECD) defines it as the implementation of a new - or significantly improved - product (good or service) or process, a new method of marketing or a new organizational method in company practices, in the organization of workplaces or in external relations (Oecd/Eurostat 2005).

This concept aims to circumscribe the object but also its impact, focusing primarily on the creative, organizational and management processes that originate "in" or "for" the market. In this conception, the innovative process is considered as a constitutive phenomenon of so-called Weberian "rational capitalism". Although this definition is strongly firm-centric, it considers innovation as the result of a process, largely relational and which involves different actors (especially universities, research centres, but also other institutions, as well as users/consumers). Another limit in economic innovation conceptualizations is that they tend to rely on technological innovations only, understood as new and more efficient ways to transform the material world. Technologies are considered at the core of any innovative processes and are evaluated in base of a mere calculation of their capacity to

produce a surplus value. Social, political and cultural aspects connected to innovation or co-creation tend to disappear from the scene. They become almost invisible. In the business sector, for instance, innovation often encompasses "the creation of new products or production methods, new ways of organizing labour, and supply sources or markets" (Miric, Petrovic and Anicic 2019, p. 128). Economic innovation places great emphasis on the relationship between basic research and applied research, and innovations can either be demand-pull, supply-driven or technology-pushed. Since the environmental issue and its relationship with the "pluriverse" of biodiversity are not crucial, the relevance and impact on society and nature in such a conceptual frame is destined to be underestimated.

1.2.7 Eco-innovation

Only recently the concept of economic innovation has been reframed by taking into consideration the environment. This environmental dimension has been included by re-framing economic innovation as "eco-innovation". Eco-innovation is understood as the "creation of novel and competitively priced goods, processes, systems, services, and procedures that can satisfy human needs and bring quality of life to all people with a life-cycle-wide minimal use of natural resources (material including energy carriers, and surface area) per unit output, and a minimal release of toxic substances" (Europa INNOVA, 2006: 7). Eco-innovations (both technological or non-technological) are seen as stimulated by the search for a balance between economic and environmental issues. The discursive adoption of this concept activated new processes for the benchmarking of innovation systems, as shown by the transition from the European Innovation Scoreboard to the European Eco-Innovation Scoreboard (see https://green-business.ec.europa.eu/eco-innovation_en).

Carrillo-Hermosilla tried to systematize the concept of eco-innovation (Carrillo-Hermosilla et al. 2010). He considers design as a crucial dimension of proactive planning that addresses both how to improve existing systems and how to create or transform to an entirely new system. From an environmental perspective, two different design rationales to innovations can be distinguished: one considers human actions incompatible with the natural environment and focuses on minimizing those environmental impacts; the other focuses on redesigning human made systems to reduce the environmental impacts of production and consumption activities. When these two perspectives are combined with the incremental/radical nature of technological change and the degree of impacts to the system, three different approaches emerge that identify specific roles and impacts of eco-innovations (Figure. 1).

Fig. 1. Typology of eco-innovations according to the radical or incremental nature of produced technological change and the level of impacts to the system.
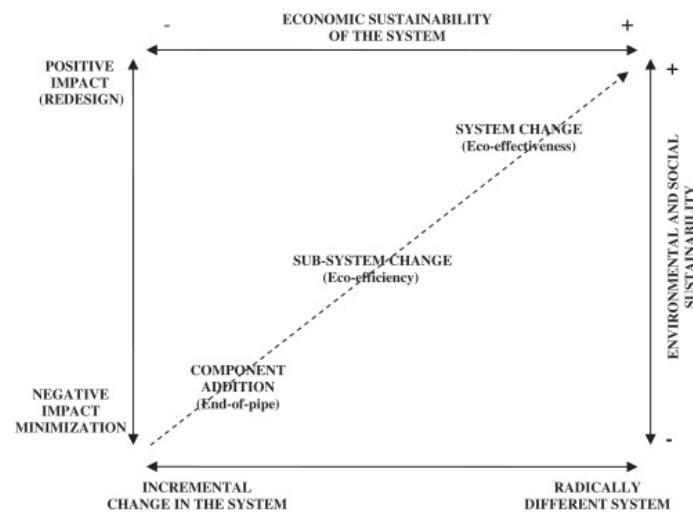
Source: Carrillo-Hermosilla et al. 2010: 1076.

1) Component addition (development of additional components to improve environmental quality, as with "end-of-pipe" technologies), without necessarily changing the process and system that generate those impacts in the first place.

2) Sub-system changes o eco-efficiency strategy (e.g., eco-efficient solutions and optimisation of sub-systems): reducing negative impacts by creating more goods and services while using fewer resources and generating less waste and pollution. These goals, however, are often insufficient because the increases in environmental efficiency tend to be erased by subsequent rebound effects.

3) System changes or eco-effective strategy: a redesign of systems promoting radical changes to reduce the environmental impacts on the ecosystem and society by focusing on industrial systems to shift from open loop to closed loop systems, in which wastes become inputs for new processes.

In this system three further different dimensions of innovation are considered:

- the user dimension: considering both user development and user acceptance. The first one in based on the crucial commitment of leading consumers in the roles of inventors and (co)-developers. In this perspective firm needs new competence to identify which users can provide valuable inputs in the idea generation and development phase. At the same time, user acceptance is also crucial in the application of eco-innovations and their perceived and resulting impacts on society.
- the product/service dimension: as a radical, redefinition of the product/service concept and how it is provided to customers, producing changes in the value-networks (value-chain and other relations) and processes which enable the delivery of the product/service.
- the governance dimension: eco-innovations require techno-institutional system-level changes coping with prevailing lock-in conditions and mechanisms. Innovations in environmental governance refer to all institutional solutions in, both, the private and public sector, aimed at resolving conflicts over environmental resources. Institutional solutions refer to changes in norms and

values potentially leading to new organisational or structural changes in a company, government or society.

1.2.8 Innovation for sustainability

The notion of "innovation for sustainability" plays a similar role but it explores a larger range of connection to the issue of biodiversity than the concept of eco-innovation. Innovation for sustainability refers to innovation that is specifically targeted to address ecological and societal considerations. It entails the translation of the three Es (equity, ecological, and economy) into the three Ps (people, planet, and profit) (Edgeman and Eskildsen, 2013). The effort for preserving biodiversity is inextricably intertwined with this idea of "innovation for sustainability, transition, and transformation". Incorporating innovation for sustainability into the practice of biodiversity conservation is seen as a strategy to induce crucial transitions or transformations toward a more sustainable and resilient approach (Leach et al., 2012).

The process of shifting away from practices that are currently not sustainable toward practices that are more sustainable is seen as a pillar of the innovation for sustainability approach. This involves developing and implementing new technologies, methods, and regulations that are expected to minimize negative impacts on biodiversity. For instance, the transition to sustainable agricultural practices that encourage farming methods favourable to biodiversity, such as organic farming, are assisted by innovative tools, platforms for sharing knowledge, and regulatory incentives. In this case, transformation refers to changes that are basic and systemic and go beyond gradual improvements. In the context of preserving biodiversity, transformation may imply rethinking and restructuring entire systems, policies, and behaviours to guarantee biodiversity conservation over the long term. Innovation for sustainability is seen as a sort of salvific platform driving revolutionary change and challenging established conventions, especially when it underlines the importance of adopting "new" paradigms in collaboration with different stakeholders with the aim to create "unique solutions" (Clark et al., 2005; Scherr and McNeely, 2008). Examples of transformative innovations include "nature-based solutions" integrating biodiversity conservation into urban planning and infrastructure development. In brief, innovation for sustainability is a socio-engineering approach that tends to build synergies and co-benefit relations between sustainability goals and the conservation of biodiversity. Innovations are evaluated in relations to their capability to generate "positive" feedback loops and enhance each other's advantages.

The development of nature-based solutions, such as green infrastructures, is considered as a crucial strategy to increase biodiversity while simultaneously storing carbon, reducing the effects of climate change, and offering various ecosystem services. More to the point, innovation in biodiversity conservation often involves the development of new technologies and practices or applying existing technologies in novel ways. This can include advancements in remote sensing, data analytics, genetic sequencing, and monitoring tools directed toward a better assessing and understanding of biodiversity patterns and dynamics. The value attributed to this kind of innovation depend also on its capacity to integrate biodiversity considerations into business models and supply chains. This trend implies the development of sustainable sourcing practices, green marketing strategies, and compensation schemes that encourage businesses to protect and restore biodiversity. Such an approach also stresses the importance of promoting "community-based conservation" initiatives, participatory decision-making processes, and incorporation of traditional ecological knowledge to enhance the effectiveness and sustainability of conservation

actions. Finally, innovation for biodiversity conservation often need specific legal instruments, financial mechanisms, and incentive schemes that support conservation actions, for instance by promoting a sustainable resource usage, or facilitating an equitable sharing of benefits derived from biodiversity.

1.2.9 Open innovation

Another concept increasingly circulating in biodiversity innovation debates is "open innovation", understood as a process by which private actors invest their resources and skills to produce a public good (Von Hippel and Von Krogh 2003). In this approach, cooperative and open dynamics of innovation are considered essential to cultivate communities that strive to keep their innovation processes available to any qualified contributor and seek to distribute their work for free. Collaboration within these communities of practices is feasible thanks to a plurality of factors (Osterloh and Rota 2007): 1) institutional conditions; 2) intrinsic motivations (pleasure of problem-solving, technological-professional interest); 3) extrinsic motivations (social and professional reputation); 4) presence of "pro-social" actors who enforce community norms. In some cases, thanks to the technical expertise and social capital they develop, some of these players take on a leadership role that helps keep the community united. Open innovation is an approach different from both the model based on private investments, driven by the exclusive appropriation of private benefits in market environments, and the model based on investments totally public. Open innovation assumes hybrid connotations (public/private, profit/non-profit, individual/collective). This concept has been widely used in the field of digital innovation and in the free software movement, but only in a few cases it has been recalled in the debate on green innovation oriented towards sustainability and biodiversity (Costa and Matias 2020). Furthermore, this model starts to be incorporated into the innovation strategies of large companies, thus making this phenomenon tend towards more top-down and market-oriented approaches (Lippolis et al. 2022).

1.2.10 Social innovation

Social conceptions of open innovation have been recovered and absorbed into the debate on "social innovation". This concept has assumed greater importance from the 60s and 70s, with reference to the processes of empowerment of marginal communities, and then it has been relaunched since the 90s, thanks to think-tanks (e.g., Young Foundation and Nesta) and to national and supra-national institutions. One of the merits of the notion of social innovation is precisely that it reduces the manageralization risk, opening the Pandora box of a panacea of technologically driven, regulative innovations oriented towards the market. However, if innovation is viewed as new ideas and approaches that work toward meeting social goals, it is necessary to understand what is the balance between a collective social purpose (environmental, inclusive socio-ecological restoration and repair, for instance), and the management of a strategy that could maximize transformative change over time, and also it is necessary to understand if social innovation is driven by competition or mutualism (Mulgan 2006), if it is monopolized by urban elites or community-driven entities, and so on. This is why in radical definitions of social innovation the need of taking a step back from the market is more emphasized than in others: the OECD's LEED Forum on Social Innovations, for instance, defines social innovation as clearly distinct from economic innovation. Social innovation "is not about introducing new types of production or exploiting new markets for the sake of exploiting them, but is about satisfying new needs not provided by the market (even if markets intervene later) or

creating new, more satisfactory ways of insertion in terms of giving people a place and a role in production" (Committee for Scientific and Technological Policy (CSTP), *Fostering Innovation to Address Social Challenges*, OECD, Paris, 2011, in TEPSIE Report).

Another definition that enjoys a high level of popularity in this sector comes from the Stanford Social Innovation Review that emphasises the importance of improving social inclusion. Social innovation is presented here as "a novel solution to a social problem that is more effective, efficient, sustainable or just than existing solutions and for which the value created accrues primarily to society as a whole rather than private individuals" (Phills et al. 2008). There is also a tendency to underline the relevance of social innovation in linking the phenomenon to new forms of social entrepreneurship based on hybrid organizations and on what is presented as the "civic" role of new technologies (Mulgan 2019; Moulaert and MacCallum 2019). Another definition on which there is strong consensus is the following: "Social innovations are changes in the cultural, normative or regulative structures (or classes) of the society which enhance its collective power resources and improve its economic and social performance" (Hämäläinen and Heiskala 2007 in TEPSIE report).

Below a synthetic representation of the main aspects taken into consideration in defining social innovation is offered, with the purpose of grouping examples of literature topics and subtopics. The authors of the table state that "research on social innovation tends to focus on 'systems and processes of change in social relations' on the one hand and 'innovation in the conceptualisation, design and production of goods and services that address social and environmental needs and market failures on the other" (The Young Foundation 2012: 6). Starting from this proposition, in the table they try to unpack these two uses of the term, creating subclusters of topics and underling key features of the main analyses.

Fig. 2 Use of the term Social Innovation

Examples of literature topics	Examples of literature topics
Processes of social change and societal transformation	• Role of civil society in social change • Role of social economy and social entrepreneurs • Role of business in social change
Business strategy and organisational management	• Human, institutional and social capital • Organisational efficiency, leadership and competitiveness • Sustainability and effectiveness of non-profits
Social entrepreneurship	• Role of individuals in creating social ventures • Behaviours and attitudes related to social enterprise • Businesses focused on social objectives with any surpluses re-invested
New products, services and programmes	• Public sector innovation • Public service provision by social enterprises and civil society organisations
Governance and capacity building	• Interrelationships between actors and their skills, competencies, assets and social capital in developing programmes and strategies

Source: The Young Foundation (2012): 8

In European Commission reports, social innovation is defined as the set of new ideas (products, services, models) that simultaneously respond to social needs and create new social relationships or unprecedented collaborations. It represents a good for society and improves its ability to act (European Commission 2013). However, due to its vagueness, the concept has been defined as a "quasi-concept", characterized by a multiplicity of analytical meanings used to act as a container for various and heterogeneous projects, while acting as a means of translation between different social worlds.

Contrastingly, the idea of social innovation for biodiversity is comparatively new. Nonetheless, references to biodiversity in the literature on social innovation are increasing (see review in Ziegler. et. al 2022), as well as examples of local success (Singh et al., 2021), although the scale of changes reported is still not great.

IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services) recognizes explicitly the concept of social innovation. Its report suggests specific ways in which social innovation could become a good strategy for the promotion of sustainability and biodiversity, that is when social innovation:

- recognizes the innovations of indigenous peoples and local communities;
- recognizes the value of locally developed innovation and experimentation;
- involves changes both in production and consumption;
- prototypes pilots and tests of policy innovations.

In an attempt to propose a systematic review of the concept of social innovation applied to biodiversity research, Ziegler et al. (2022) distinguish between three main areas of interest: nature-based solutions, technology and participatory governance. This model implies a variation in conceptualizations and a different relevance of social innovation as a driver for biodiversity. Social innovations for biodiversity may refer to changes in patterns of thinking, changes in moral values and changes in concepts and identities, thus spanning from "protection of", to "precaution for", to "cooperation with" Nature Based Solutions, and finally reaching the status of "assimilation with nature" (more-than-human), accounting for a path towards "nature positiveness". It is important here to notice that justice and nature are considered as strongly connected in this evolutionary process. Indeed, cultural diversity and biological diversity are considered as closely linked: where one decreases in favor of homogeneity, the other does so too (Verschuuren and Brown 2019). Climate justice and biodiversity justice are also interlinked.

Fig. 3. From Nature Protection to Nature Positive Society
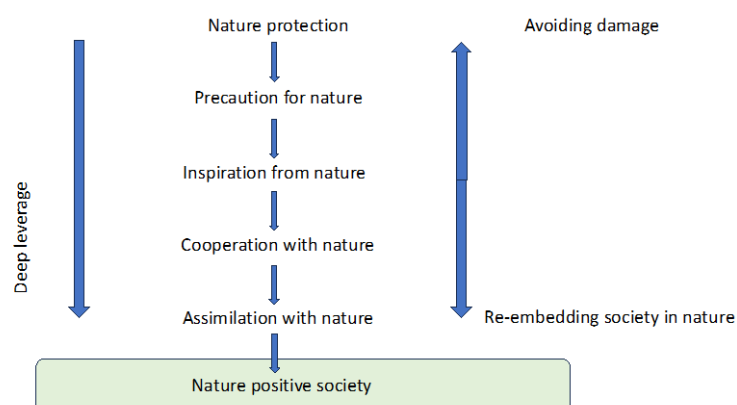
Source: our elaboration

The above figure illustrates the evolution from traditional nature protection/conservation to a society that has re-embedded its actions in nature and natural processes. This evolution involves a gradual conceptual change in human-nature relations, resulting from ever deepening leveraging mechanisms.

In the IPEBS model transformative biodiversity innovations are social innovations that bring along structural change both in society and in nature. They are transformative because they bring a system over the edge of a tipping point, causing fundamental change in the interactions of its components. Innovations with deep leverage points can involve the epistemic re-embedding of humans in nature, the challenging of moral values in a social practice or knowledge system (e.g., decolonizing) and an effort of incorporating nature in the construction of social identities. When ecological and social resilience re-enforce each other, a significant contribution to a nature positive society may result.

1.2.11 Synthesis

The table below summarizes the different definitions analyzed so far and compares the different definitions of innovation, highlighting some fundamental characteristics, particularly in relation to the relationship with the environmental dimension and biodiversity.

Table 1 – Comparing varieties of innovation for biodiversity and nature positive society

Variety of Innovation	Basic definition	Connection with the environmental / biodiversity issue	Reference
animal innovation	new or modified learned behaviors and novel behavioral variants introduced into a population's repertoire	Indirect and mostly in evolutionary terms	(Ramsey, G., Bastian, M. L., and Van Schaik, C. 2007; Reader, S. M., and Laland, K. N. 2003)
cultural innovation	Procedural and incremental process of transformation of culture and social practices	in relational terms in interaction with social practices and human ways of attributing meanings	(Godin 2016; Ufer and Hausstein 2022)
retro-innovation	Purposeful revival of historic practices, ideas and/or technologies	knowledge systems opposed to dominant modernist agricultural practices	(Zagata et al. 2020; Stuiver 2006)
niche innovation	carried and developed by small networks of dedicated actors, often outsiders or fringe actors	not crucial, despite some cases take into account the environmental dimension	(Geels and Schot, 2007; Lopolito, Morone and Sisto 2011; Witkamp, Raven and Royakkers 2011)
process-oriented innovation	as a result of governance processes that emphasize the relationality between society and nature to create positive relational (place-based) bonds	based on relational values as place-specific meanings of nature	(Pascual et al. 2017; 2023)
economic innovation	the creation of new products or methods of production, supply sources or markets	nature is "hidden" or implicitly commodified	(Miric, Petrovic and Anicic 2019; Oecd/Eurostat 2005)

eco-innovation	economic innovation with a life-cycle-wide minimal use of natural resources and release of toxic substances	in terms of technical and performative eco-efficiency or eco-effectiveness	(Carrillo-Hermosilla et al. 2010)
innovation for sustainability	specifically targeted to address ecological and societal considerations	revolutionary change of conventions and paradigms	(Leach et al., 2012; Edgeman and Eskildsen, 2013)
open innovation	private actors invest their resources and skills to produce a public good	not mentioned directly despite some cases can take into account the environmental dimension	(Lippolis et al. 2023; Costa and Matias 2022)
social innovation	oriented toward the satisfaction of new needs not provided by the market, giving people a place and a role in production	transformative biodiversity innovations as a potential goal of socio-innovative experiments	(Ziegler et al. 2022; Verschuuren and Brown, 2019)

2 Theoretical frames to analyse the launch and experimentation of innovation

In this paragraph, we analyse various theories used to understand transformative change aimed at addressing biodiversity innovation. We highlight the potentials of consolidated theoretical frames with respect to the analysis of innovative processes, in particular those linked to the enhancement of environmental sustainability and biodiversity. Distinguishing these theoretical frameworks in respect to their different analytical level (micro, meso, macro), we identify what are the assumptions and variables that characterize each approach, as well as the connection with the techniques and methods applied. At the end, we also try to establish potentialities and risks in the use of these approaches taking into consideration BIOTraCes specific objectives and goals.

2.1 Micro level

2.1.1 Theory of Planned Behaviour (TPB)

The Theory of Planned Behaviour (TPB) is a theoretical framework used for launching and testing new ways to protect biodiversity. The TPB is a well-known psychological theory (Ajzen 1991) that explains and describes how people act, especially when making decisions and taking actions with a goal in mind. It has been used in many areas (Ito 2023; McEachan et al. 2011), which makes it important for efforts to protect biodiversity. The TPB says that intention to perform a behaviour best predicts that behaviour. Intention to perform a behaviour is influenced by: 1) Attitudes: they refer to how people feel about an action and the results of that behaviour. In the case of biodiversity, for example, this could mean how they feel about conservation practices, using resources in a sustainable way, and protecting the environment; 2) Subjective norms as the social pressures or expectations that affect people's choices and actions (this includes, for example, how family, friends, the community, and society's standards about biodiversity conservation and sustainable practices affect them); 3) Perceived behavioural control as the degree to which a person thinks he/she can control behaviour. This factor looks at how easy or hard people think it is to take steps that help protect biodiversity, for example.

Ajzen's TPB was further extended in various studies by including other constructs, also in the sustainability field. For example, using TPB, the intention to perform vermicomposting was explained and predicted (Rastegari et al. 2023).

There are potential strengths of applying the TPB approach in the study of biodiversity innovation: a) established framework, meaning that TPB is a well-established and widely used theoretical framework, so researchers are familiar with its concepts and how to use it; b) predictive power: TPB has demonstrated good predictive power in various contexts. For example, researchers can make accurate predictions about how likely it is that people will use innovative practices to protect and conserve biodiversity if they understand the factors that affect behaviour intentions; c) flexibility: TPB can be used to study different types of biodiversity innovations because it can be applied to other behaviours and situations. TPB can teach us a lot about how people make decisions and act, whether using new sustainable practices, participation in conservation programs, or using new tools.

Potential weaknesses of the TPB approach in the study of biodiversity innovation: a) limited contextual understanding: While the TPB gives insight into the factors that affect individuals, it may not fully capture the complexity of biodiversity innovation, which often involves complex socio-ecological systems;   b) lack of time dimension: TPB primarily focuses on the immediate intention to engage in a behaviour, but it does not take into account how intentions change over time; c) overlooking collective action: TPB might not fully capture the complexity of collective action involved in biodiversity innovation, and does not explain how social influences operate within communities and institutions for effective conservation effort.

2.1.2 Plural Values Approach

Since recent years, there is an increasing body of literature and methodologies to conceptualize the idea of a Plural Values Approach. Especially since the 2022 IPBES values assessment report, there is now an uptake in approaches to scientifically investigate and elicit nature's diverse value expressions. Policies typically respond to instrumental values that are easier measurable and quantifiable, such as indicators around air, water, or soil quality, that can translate into economic or physical health impacts from the supply of ecosystem services (e.g., food and fibre provision, and recreation through tourism). However, more intangible contributions from nature to people (e.g., artistic, spiritual, sense of place, identity, etc.) are either not accounted for or considered secondary to market-related and commodifiable ecosystem services. While relational values are expressed in everyday life by people and people nourish them, they are typically more difficult to measure and thus less accounted for in policy decisions. While there is an increased interest in identifying and describing relational values vis-à-vis instrumental values at the local level, in scientific literature, so far, most studies have looked at relational values expressed or articulated by individuals; yet we argue in the context of conceptualizing biodiversity innovation, a focus on eliciting and formulating shared relational values by local communities is necessary. This has conceptual as well as methodological implications, as eliciting shared relational values require defining what is understood as "the community" and thus its boundaries. Further, any given individual can have multiple identities as connected to different communities (e.g., neighbourhood community, activist community, etc.). The community-level shared relational value may vary in how it is expressed by a given community and by the same individual. Methodologically, this also implies that a mix of deliberative approaches may be required to understand how shared relational values are expressed.

The rationale behind policy measures for the protection of biodiversity has traditionally focused on protection of nature and its benefits for humans' sake (instrumental value) or for the sake of nature itself (intrinsic value). This has led to the ignoring of the way individual people and communities value nature through their relationship with it. Relational values are closely related to people's conception of a "good life" and individual or collective sense of identity. This includes both relationships with nature as well as with people through nature. Collective identities can thus be rooted in certain places. Nature can furthermore act as a vehicle to connect with people and foster social cohesion. Through shared experiences in nature social bonds can be strengthened, which can then be harnessed for collective action in biodiversity protection. Conservation based on intrinsic

or instrumental valuation of nature can often be seen as something imposed on communities by outsiders. Fostering existing relationships to places, on the other hand, can help to collectively negotiate conservation activities as "good stewardship" (Chan et al. 2016). Framings that are based on relational values such as social ties to places could therefore bring "innovative tools to ecosystem assessment and conservation programs, and potentially enhance the success of these initiatives" (dos Santos and Gould 2018).

In previous uses of this framework, it is applied the Q-method to study different perceptions of society-nature relationships in urban environments based on a plural values framework. The objective was to elicit social perspectives on how urban residents in the context of a specific case study place relate to nature. The focus of the study was understanding broader value framings held by residents, including instrumental, intrinsic and relational values that express both direct relationships between nature and society, but also between humans through nature. In this study, the authors found that especially the communal aspect of (urban) nature, such as sentiment of collective identity through nature, social cohesion, and shared memories also with culturally diverse community members, has been received very differently by study respondents. That is, while values of nature are usually dealt with in the literature as overall positive, it was found that study participants partly showed strong connections to relational values expressing negative sentiments towards diverse members of the urban community. The study hypothesizes that a policy framing and a governance process framing positive community aspects of biodiversity can help advance towards a nature-positive society.

2.1.3 Synthesis

The table above summarizes the main conclusions regarding the approaches examined.

Table 2 – Micro level theories for the analysis of nature positive/biodiversity innovations

Theory	Method Adopted	Key assumptions	Key variables	Strengths	Weaknesses
Theory of Planned Behavior (TPB**)**	Survey	intention to perform a behavior best predicts that behavior	-Attitudes -Subjective norms -Perceived behavioral control	-Established framework -Predictive power -Flexibility	-limited contextual understanding -lack of time dimension -overlooking collective action
Plural values Approach	Deliberative Methods	community-level shared relational value affects the implementation of environmental policies	-Instrumental values -Intrinsic values -Community identity	-Considering not-instrumental values -including the community dimensions	-not consider power mechanisms and social exclusion dynamics

2.2   Meso level

2.2.1 Structural Theory of Networks (STN)

In STS the relational and interactive dimension of innovation has been underlined in many definitions of innovation. The underlying concept of network theory is that of embeddedness proposed by Granovetter (1973; 2017). Granovetter reiterates that relational analysis is always necessary to understand phenomena such as trust, solidarity, cooperation, power, norms and social identities. The presence, intensity and quality of

these relationships influence most of the socio-economic phenomena in which we are immersed, including innovation.

Social networks are composed of nodes related to social identities and organized in structures according to the principle of "homophilia" which leads individuals to associate mainly with other people who share their same characteristics based on the principle that similarity generates connections. The networks could be organised in "small worlds" stratified and interconnected, but multidimensional and this is what allows people to move through diverse contexts to get both cognitive resources (i.e., information) and normative resources (i.e. trust).

The configuration of networks changes both in space and in time, both at an individual (in the history of the single company or single social actor) or sectorial levels. In fact, networks are based on economic and institutional infrastructures that support the creative processes, the transfer and commercialization of knowledge, as well as the circulation of capital flows. Some scholars have spoken of learning regions (LR) (Florida 1995), precisely striving to connect the relationship between innovation processes and networks in regional development. This literature tends to underline the role of socio-cognitive resources centralized in hubs (for example, the university, research centres, etc.), and the role of social capital and trust in facilitating collaboration between actors in interactive mutual learning processes.

Gonzales and Parrot (2012) suggest that socio-ecological systems could be seen as a network of many heterogeneous elements, including human actors, institutions and resource users, as well as natural components, such as land patches, animal species, etc. The several relationships between these different entities shape complex, dynamic networks of social–ecological interdependencies. Once described as networks, a variety of network metrics can be adopted to quantify and evaluate the resilience of socio-ecological system to external or internal perturbations.

STN is based on network analysis techniques that are grounded in relational data (contacts, links, connections that constitute a relationship between two or more actors). Therefore, the unit of analysis is not individuals but the links between them. According to Hanneman and Riddle (2005), the main dimensions of analysis are the following: 1) density: which measures the degree of social integration of a group of individuals and in some way also its inclusiveness; 2) centrality: which measures the overall structure of the network and the position of the individual actor in respect to the others; 3) cohesion: through the decomposition of the network into subgroups (cliques). An extensive example of the use of social network metrics in the analysis of socio-ecological systems is visible in the work of Gonzalez and Perrot (2012). This approach is useful also to measure and identify lock-ins and power law mechanisms. Other potential advantages of network theory are: 1) assumes that networks are not static but evolve according to time dynamic rules; 2) complementary also to systemic analysis. However, STN has also several limits: 1) excessive structuralism in the conception of networks and their social roots; 2) poor valorisation of individual agency processes.

2.2.2. Diffusion of Innovations Theory

Diffusion of Innovations Theory can be applied to understand the process motivating people, organizations and social groups to adopt and engage in innovations (e.g., Kronenberg, Bergier and Maliszewska 2017; Mascia and Mills 2018; Nawrotzki and Pampel 2013). As the innovation gains momentum, early adopters within the conservation community and related sectors join, recognizing the potential benefits and positive outcomes. This theory can help explain the factors influencing people decisions, such as perceived advantages and compatibility with existing practices. Subsequently, the innovation spreads to the early majority and late majority, who may adopt it once they witness its effectiveness and reduced risks. However, there may still be a group of slow adopters who are resistant to change and may only adopt transformative innovations when they become the prevailing norm or a necessity. Overall, the Diffusion of Innovation Theory

provides valuable insights into the adoption dynamics of transformative innovations in the context of biodiversity conservation, shedding light on the factors influencing their acceptance and integration within society. To this end, several scholars employed Diffusion of Innovations Theory which suggest patterns via which social change occur and spread (Rogers 1981, 2003; Valente and Rogers 1995). The properties of innovation, adopters, channels via which communication on innovation will be delivered, the time span required to adopt the innovation and properties of the social system are key components determining the pace at which innovation will diffuse. Notably,

- properties of innovation refer to the categories that innovation represent (e.g., ideas, practices, products, etc.);
- adopters refer to the potential users of innovation such as individual people (e.g., citizens, consumers, politicians, activists, etc.) or groups of people (e.g., (non)governmental or business organizations, social groups, movements, countries, etc.);
- channels via which communication on innovation will be delivered refers to means or groups via which innovation is promoted (e.g., social or regular media, certain groups, influencers, etc.). Communication channels serve the purpose of informing potential adopters about the innovation. The intensity and quality of communication might determine the pace of a diffusion;
- the time span required to adopt the innovation refers to a customized amount of time required for the adoption and spread of innovation;
- properties of the social system refer to interaction patterns between components of a social system;
- Conceptual, social or technological innovations go through the universal processes that could be roughly divided into the following phases: 1) acquisition of knowledge about or building awareness of existing innovation – exposure to innovation but no interest or enough capacity to adopt innovation; 2) persuasion – active seeking of information about innovation; 3) decision - evaluation of pros and cons of innovation that can lead to adoption or abandonment of intentions; 4) implementation – adoption of innovation while proceeding to explore its properties and usefulness further; 5) confirmation or continuation - adopters seek confirmation, both internally and from their group, to alleviate potential cognitive dissonance and ensure the decision to continue using the innovation is validated, with change agents playing a role in this process.

People, organizations or social groups vary in their adoption pace for a given innovation. Diffusion of Innovations Theory suggests that innovators are pioneers who are open to taking risks and embracing new concepts, ideas or items, demonstrating a willingness to adopt technologies that could potentially encounter setbacks or failures. The early adopters exhibit a more cautious approach towards adopting innovations compared to innovators, employing a thoughtful selection process for adoption. The early majority embraces an innovation, but their adoption time frame is notably longer than that of innovators and early adopters. They typically interact with early adopters and rarely occupy positions of opinion leadership within a system. The late majority adopts innovations later than the average adopter, often approaching innovations with a certain degree of scepticism, well after most of the society has already adopted them. The late majority tend to be sceptical about innovations and do not usually hold positions of opinion leadership. The slow adopters are the last to embrace innovations, lack opinion leadership, resist change agents and favour tradition while relying primarily on family and close friends for opinions.

Overall, the main advantage of this process is its focus on motivation and engagement in innovation process, distinguishing phase and type of actors, pointing out the relevance of communication and legitimation process. Its main limit is more linked to its linear, ordinated and progressive vision of innovation processes which often does not correspond to reality. Innovation is a complex ambiguous, and fragmented that may not follow a specific order.

2.2.3 Landscape Approach and Urban Political Ecology

Landscape approach emphasizes the interconnectedness of human-environmental relations in space and time, where practices in relation to environment creates certain conditions. It is not enough to view innovation as happening in a discrete space, time or sector. Within this approach, innovation is part of ongoing/pre-existing relations in a particular landscape that affects future developments in sometimes unintended ways (e.g., Stenseke 2020; Stenseke et al. 2012).

Stenseke et al. (2012) demonstrate the difference between social-ecological systems and a landscape approach in that the systems approach tends to emphasise resource use as something discrete and has a less developed vocabulary to deal with interactions in space and time between different forms of resources, their connected uses, ecologies, institutions and social ties. The landscape approach is instead specifically used to handle complex spatiotemporal relations in viewing the landscape as an arena where various processes and actors constantly coexist over time. By analysing how specific innovations intervene in spatiotemporal complexities scholars form a fuller picture of their potential benefits and deficits. However, we need to be aware of how innovations are connected to structures such as global market capitalism and how those structures constrain, enable or affect the development of innovations over time and space (e.g., Devine and Baca 2020; Peluso and Vandergeest 2020). These theoretical frames in combination highlight that innovations do not appear in isolation but are instead part-and-parcel of ongoing human-environmental relationship that transcends different scales. Innovations are not only the product of immediate circumstances but instead tightly interwoven with economic, ecological, political, social and historical dimensions which are strongly bound to contexts. Both approaches raise a critical awareness when studying biodiversity innovations that needs to be considered, especially when developing strategical or policy directed perspectives from local cases. The weakness is that both are more difficult to communicate directly with the public and might not serve as an inspiration but instead as a source for caution. However, considering innovation as part of a wider political ecological network in an interrelated landscape also fundamentally enables a fuller understanding of the wide-ranging consequences that such developments may have into the future, including positive ones.

The landscape approach is highly holistic and considers many types of contextual variables, emphasizing material practices in space, and from that their connected institutions, social formations and symbology. The links between words as for example expressed in policy documents and material events/actions on-the-ground are important aspects, as every solution to globally perceived problems require physical actions that are also performed locally.

This landscape approach pays close attention to spatiotemporal interconnectedness, and physical path-dependencies of different processes and objects (human and non-human). Instead of emphasizing different activities as part of specific systems, the landscape approach emphasizes how different aims, actions, projects and processes coincide in space. Forestry, for example, is part of a wider system of forest resource use but is also practiced in a geographic space with other forms of land use and by people who are also engaged in other types of activities. Different land use interests compete over the same geographic space. Innovations that change human-environment relations in a given area are therefore always not only productive, but also disruptive and changing existing relations in area, out-competing some activities and promoting others. While many of these might be intentionally out-competed, others might not. Innovations thus interfere with ongoing processes in the landscape, restricting and enabling future developments also in other areas and sectors. This is also related to studies of the unintended consequences of sustainability initiatives (Jones et al. 2022), but apart from considering unknown parts of the specific social-ecological system as a cause, a landscape approach broadens this view considerably.

A political ecology perspective on innovations involves paying attention to how innovations may benefit some people above others as well as how they interplay with global market capitalism. Like the landscape approach, this involves contextualizing innovations but

looking more closely at vertical relations of scale when it comes to questions of power, institutions and economy. This also involves contextualizing current relations by looking at this from a historical perspective. A critical perspective on conservation efforts is tied to this, and how biodiversity innovations interact with existing power relations, land tenure, resource ownership and economic interests. The economic ties which different types of innovations are tied to are important to analyse, especially ties to the wider international sector involved.

On this theoretical framework, the specificity of the Urban Political Ecology approach arises. As summarized by Natasha L. Cornea (2019), Urban Political Ecology (UPE) is a conceptual approach that understands urbanization to be a political, economic, social, and ecological process, one that often results in highly uneven and inequitable landscapes. Cities are not seen as the antithesis of nature but rather are a "second nature", representing the dominant form of living in the contemporary age. Those drawing on UPE reject as false any dichotomy between nature and society. A central concern of much UPE scholarship has been in unpacking the ways that urbanization and cities rely on the transformation of biophysical matter into commodities and tracing the flows of these commodities into and through cities, understood as a metabolic process. Urban political ecologists argue that these processes cannot be understood in isolation but rather are deeply embedded in the social, political and economic systems that shape the context in which they develop. Thus, a significant strand of research in this sub-field has focused on the infrastructural arrangements of capitalist modernity – particularly networked water. Urban political ecology scholarship is often characterized by a deeply historical and material understanding of the city and seeks to capture the multi-scalar process and relationships of power that shape urban landscapes. The researcher's task should therefore be not only that of making this nature-city connections clearly emerge but also that of unveiling the socio-environmental exploitation, injustice, oppression mechanisms which come in place when nature is transformed, commodified and inserted into systems of circulation and urban metabolization.

This dualism nature/society can be also traced in the more recent critique of human impacts on nature (modernization, industrialization, urbanization) which has inspired some environmental, ecological and sustainable city movements. These identify the city as the anthesis of nature, as a parasitical entity and refer to nature as some kind of moral order to which human being should aspire. As several scholars highlighted the re-proposition of a nature/culture dualism relationship has for long impeded a thorough appreciation of environmental problems. As Lewontin (quoted in Swingedouw and Kaika 2000: 570) pointed out, "a rational environmental movement cannot be built on the demand to save the environment, which, in any case does not exist… Rather we must decide what kind of world we want to live in and then try to manage the process of change as best as we can approximate it". Also, Swyngedouw and Kaika (2000: 571) stress how "there is no such thing as an unsustainable city in general, but rather there are a series of urban and environmental processes" that negatively affect some human and non-human beings, while benefitting others: "A just socioenvironmental perspective, therefore, always needs to consider the question of who gains and who pays and to ask serious questions about the multiple power relations through which deeply unjust socioenvironmental conditions are produced and maintained" (ibidem).

The idea was that of creating modern cities and homes as autonomous "space envelopes" independent from nature's whims. Paradoxically this programming vision was predicated upon the establishment of intricate networks and flows (for instance of water, food, gas, electricity), "social power relations and capital investment cycles, which, in fact, not only did not separate nature from the city, but instead wove them together more closely into a socio-spatial continuum" (ibidem). Not only nature and the city are not autonomous entities, but they are also hybrids "neither purely human-made nor purely natural" (ibidem).

Reflecting the origins of this approach in Marxist urban geographies this analysis has often been underpinned by a broader critique of the ways that capitalist production shapes cities in deeply unjust and uneven ways. In recent years a subset of scholars are increasingly

influenced by post-structuralist understandings of power and seek to illuminate how other forms of social power are (re)produced through the production of socio-natures. As the field has grown scholars have increasingly applied an UPE lens to the analysis of a range of resources including water, urban greenery, food, waste and other discards, sanitation, electricity, and climate change. Water, in particular, was at the centre of such analysis. As it flows from spaces of production to spaces of consumption undergoes several treatments and changes in "its physical, socio-political and cultural character" (ibidem). Similarly, there is nothing unnatural about the city as David Harvey (1996) has put it for New York city. Bricks of which our cities are made are nothing more than nature (in the form of clay/fired hearth) transformed through the input of human labour and capital investment. This, often, messy socio-spatial continuum is not always evident and perceptible. For instance, the intricate infrastructural system made of networks and pipelines which bring natural elements into the city, is often hidden or obscured.

2.2.4 Synthesis

The table above summarizes the main conclusions regarding the approaches examined.

Table 3 – Meso level theories for the analysis of nature positive/biodiversity innovations

Theory	Method Adopted	Key assumptions	Key variables	Strengths	Weaknesses
Structural Theory of Networks (STN)	Social Network Analysis	Knowledge is sticky on social networks and social capital and trust are key factors in facilitating collaboration and mutual learning processes	-social integration of a group and its inclusiveness -the position of core actors in respect to the others -presence of subgroups (cliques)	-detect lock-ins and power law mechanisms -consider the dynamic nature of networks -complementary to systemic analysis	-excessive structuralism -poor valorization of individual agency processes
Diffusion of Innovation Theory	Mixed Methods	process motivating people, organizations and social groups to adopt and engage in innovations	-properties of innovation -adopters -channels -the time span -properties of the social system	- Focus on motivation and engagement in innovation process -Distinguishing phase and type of actors -Relevance of communication and legitimation process	-linear and progressive vision of innovation processes which often does not correspond to reality
Landscape Approach and Urban Political Ecology	Spatial and documentary analysis	interconnectedness of human-environmental relations in space and time, refusing the dichotomy human vs nature	-Infrastructures -Power and Relational dynamics -Time	-focus on the multi-scalarity of innovation and relationships of power	-in some application it could produce mainly descriptive analysis

2.3 Macro level

2.3.1 National or Regional Innovation Systems (NIS/RIS)

Comparative political economy and the new economic sociology identified a specific approach to analyse and compare national or regional innovation systems (NIS/RIS) (Lundvall 1985).

The OECD was the first group to use it in a series of studies and researches that underlined its potential both in terms of analysis and of policies to support innovation. The concept has also been implemented by the European Commission, the United Nations Conference on Trade and Development (UNCTAD), the US Academy of Sciences and various other national governments. NIS therefore establishes itself as a policy concept, that is, as a concept useful for guiding not only research but also public policies. We can define NIS as "all the important economic, social, political, organizational, institutional and other factors that influence the development, diffusion and use of innovations" (Edquist 1997, 14). This approach insists on the importance of policy processes for the construction of local collective competition goods (Crouch et al. 2004).

Scholars who fall within such systemic approach focus not only on the economic aspects, but also on the social and political ones, paying attention to the origins and transformations of the institutional context in which innovations take place. Another qualifying aspect of this approach is that it adopts a geopolitical criterion of definition, assuming national states or specific regions as the unit of analysis, for which there are marked economic, political, social and cultural differences at the national/regional level which may influence the institutional and organizational configuration of the innovation systems. However, the analysis of the NIS/RIS is also confronted with different territorial and geopolitical scales (sub local or sectorial) and does not deny the relevance of extranational regulatory bodies and policies that could intervene also in conditioning or transforming national/regional systems.

The starting assumptions of this systemic approach are four:

1. National/Regional economies present a variety of specializations, which do not only concern production and commercial structures but also cognitive ones. These productive and cognitive specializations are interdependent and co-evolve in a path dependent manner;
2. Knowledge is "sticky" and does not circulate easily from one place to another, because it is embedded in people's minds and bodies, in business routines, in interpersonal and inter-organizational relationships;
3. Individuals, firms and other organizations never innovate in complete isolation and thus an "interactionist" perspective is needed to study innovations;
4. Finally, (heterogeneous) plurality of actors and institutions involved in innovation processes requires an analytical holistic approach, interdisciplinary and historical-evolutionary research sensibilities.

Recently in the work of Isaksen et al. (2022) emerges the need to reorient the concept of Regional Innovation System to connect it to grand societal challenges, such as the so-called "ecological transition". For this reason, they talk about Challenge Oriented Regional Innovation Systems (CoRISs) highlighting how RISs can be reconfigured in response to this issue (figure 4).

Fig. 4. Regional Innovation Systems for sustainable transitions

	RIS reorientation strategies	RIS transformation strategies
Characteristics	Build on and reuse competences, actors, networks and institutions in existing RISs. Fit into existing production and market system	Include several new types of actors, networks and institutions. Require changes in production and market systems
Support for sustainable transition	Reusing & recombining existing assets	Creating (importing) new assets & destructing old assets
Policy strategies	Build on and adapt existing regional innovation policy for new sustainable goals	Create new policy for sustainable transitions

Source: Isaksen et al. 2022: 2129

Policy translation of innovation in NIS and RIS is seen as the results of what is called "The Triple Helix", a structural collaboration and dialogue between three important players: Industry, University and Government (Etzkowitz and Leydesdorff 2000). However, this type of approach it has been criticized because innovation policies generated within a triple helix system could be narrowminded and undemocratic. In this way, innovation and entrepreneurship policies can work to exclude specific groups in innovation and entrepreneurial processes, thereby perpetuating several inherent problems linked to gender, social class and ethnicity, and maintaining elitist approaches to innovation, excluding civil society. Grundel and Dahlström (2016) suggest enlarging the mechanism to a quadruple helix system must, including a fourth dimension - civil society (citizens, NGOs, labor unions, etc.) - in the innovation system, or even including a fifth helix represented by the natural environment.

Edquist (2005) has elaborated a list of the ten main activities carried out by the NIS which can also be assumed as variables necessary to detect and compare the different innovation systems based on the action of the various institutional actors that compose it:

1. produce new knowledge through RandD;
2. build skills for human capital, through the school-university system, professional training, etc.;
3. to found new markets;
4. articulate qualitative requirements for new products/services, with reference to the needs of the demand;
5. create and modify the organizations necessary for the development of new fields of innovation;
6. generate networks - market and otherwise - to encourage the circulation of knowledge;
7. create and modify institutions that are able to provide constraints and incentives useful for innovation;
8. carry out incubation activities in support of new initiatives;
9. secure funding for innovation;
10. provide qualified consultancy services (technology transfer, commercial and legal information, etc.).

The main strengths of the National/Regional System approach are:

- the comparative and systemic dimension of the approach which tends to enhance the interaction between different socio-institutional spheres and conditions;
- the openness to the combination of analytical methods and perspectives, bringing together analysis of secondary data, with historical-evolutionary analysis of processes and policies;
- the robust presence of classifications of national innovation systems that can be applied to read the different contexts also in a diachronic and longitudinal way.

- recent declination in the analysis of sustainable eco-innovations.

The main limitations of this approach are:

- it was mainly created to explain the processes of "economic innovation";
- it has often been accused of excessive rigidity and of overestimating path dependence mechanisms, reifying the classifications produced and creating little space for the recognition of more grassroots processes of change and transformation in progress;
- a critical perspective on capitalism where economic organizations are missing;
- it does not recognize the most avant-garde processes of change, limiting itself to those that have reached a higher level of institutionalization;
- risks of binary reductionism, applying in a dichotomous way rather than continuing the actual possession of the various systemic characteristics functional to innovative processes;
- it does not consider in its foundation the relevance of the natural system as part of the innovative ecosystem.

2.3.2 Systems Theories

General Systems Theory was proposed by Ludwig von Bertallanffy as a mean for describing the reactions of the sector towards bio-innovations. General Systems Theory might be helpful to address the interplay of the social and the ecological. According to Niklas Luhman (1995) Social Systems Theory can be used to study discursive strategies in the communications systems in various societal systems that correspond with high impact sectors and see how bio-innovations lead to contingencies and ambivalences. Social systems theory is a communication theory, but one that tries to account for the whole of society. Next, Polysystem Theory (PSTs) introduced by Itamar Even-Zohar (1990) can be used to reflect on how power structures relate to heterogeneity, and try to create homogeneity for more control, which is done by supporting specific repertoire and canon to adhere to. Thus, in its basis it is a cultural theory. This theory describes innovation related to different centres of power. It describes "the system", its dynamics and how a system survives attempts of modernization, it describes the transfer of innovative to canonized practices, and how this process is controlled by power structures. The canon provides models to adhere to for those who need to comply with the regulations and privileges of those in power. Power structures strive for homogeneity for reasons of more control, to stay in power position. Homogeneity is achieved by controlling repertoires of cultural activities which are derived from the canon.

PST sees the periphery of the system around a power centre as chaotic. Here innovations are born, sprouting from ambivalences. These innovations often attempt to enter the system with the aim to penetrate the canon. This may or may not happen, depending on how the centre of power responds. The theory has elaborated this exchange process.

This theory has been designed for research but has been used for many different purposes. Especially the tensions between regions with strong identities and countries are widely researched in polysystem theory. This theory thus could help BIOTraCes to discuss lifestyle innovations and lifestyle repertoires, to discuss power centres that interact and intersect, and which keep the privileges untouched. Polysystem theory builds on Russian semiotics and structuralism. Despite, it is particularly useful for post-structuralist work, because of its focus on discourse, language and power exerted by words. A change of system can be the result of a leverage process. Here, scholars focus on the so-called deep leverage points (figure 5). The deepest points have to do with the change of mind-sets and paradigms, as explained above. The deep leverage points (they could also be called "social tipping points") should be seen as mechanisms of change resulting from a discursive process. Communication is important, because it accounts for the way a social system relates to its

environment, which consists on other social systems, and how systems observe and signify changes in nature, as well as their own observations of changes in nature.

Fig. 5 System Change Mechanisms
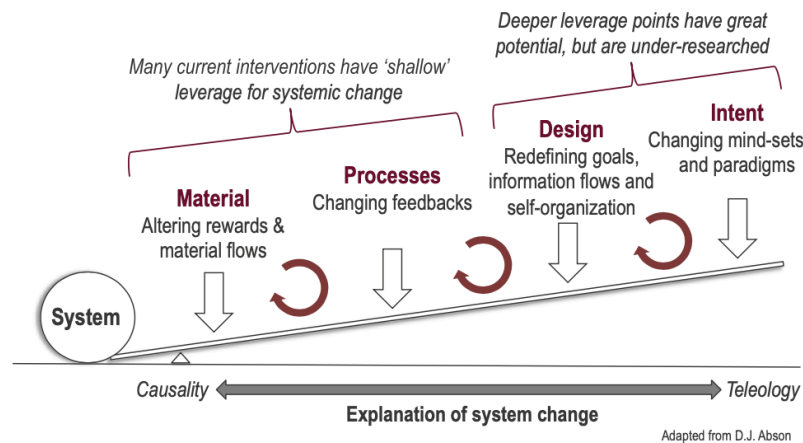
Source: Abson et al. 2017

2.3.3. Sustainability Transitions

The Sustainability Transitions is another theoretical framework that can potentially be beneficial for the launch and experimentation of various forms of innovation in promoting, protecting, or refreshing biodiversity. Sustainability Transitions framework allows decision-makers and stakeholders to adopt a more systematic and holistic approach to promote, protect, and refresh biodiversity. Markard et al. (2012) define Sustainability Transitions as "long-term, multidimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption". Smith et al. (2005) add that one thing that makes Sustainability Transitions unique is that governance and guidance often play a big role. Significant shifts occur across many dimensions during a transition, including material, organizational, institutional, political, economic, and socio-cultural. Transitions are complex processes involving a wide variety of actors and often occur over extended periods of time (for example, fifty years or more) (Markard et al. 2012). During such a shift, new goods, services, business models, and organizations come into being, which partially supplement and partially replace the ones already in place (Markard et al. 2012). Applying this theory to biodiversity innovation involves identifying and supporting innovative practices, technologies and policies to drive sustainable biodiversity conservation and management shifts.

The following are some examples that could be included in an analytical presentation of the Sustainability Transitions framework:

a) Transition Management: It focuses on managing and assisting the transition process involving various stakeholders. These stakeholders include governments, corporations, non-governmental organizations (NGOs), local communities, and scientists. It emphasizes the necessity of working together and making decisions jointly to co-create new solutions for preserving biodiversity and sustainably managing resources. Transition management is best understood as a process of reflexive and evolutionary governance drawn from conceptualizing current sectors as complex adaptive societal systems (Nill and Kemp 2009). The implementation of transition management on regional and local levels has been observed in various contexts, such as in cities (Bulkeley et al. 2010).

b) Innovation and Experimentation: The idea of experimenting with and learning from real-world interventions is one of the most important aspects of the Sustainability Transitions

framework (Meadowcroft 2011). Based on a systematic literature review, Sengers et al. (2019) define experimentation as "an inclusive, practice-based and challenge-led initiative designed to promote system innovation through social learning under conditions of uncertainty and ambiguity." Innovation and experimentation foster various ideas at diverse scales, ranging from community-based efforts to large-scale policy experiments, rather than depending primarily on top-down techniques, which are the most common alternative. This enables continuous learning and adaptation of strategies based on the outcomes of these experiments.

c) Multi-level perspective (MLP): MLP recognizes that sustainable transitions occur within a complex system of interacting levels. These levels include the niche level, where innovations emerge and develop; the regime level, which is the dominant system of rules and practices; and the landscape level (El Bilali 2019; Geels 2011; Schot and Geels 2008), which is the broader socio-cultural, economic, and political context. To successfully innovate in the field of biodiversity conservation, it is essential to have a solid understanding of the interactions between the different levels.

d) Policy Mixes and Instruments: Sustainability Transitions aim to use a combination of different policy instruments to encourage the preservation of biodiversity and the development of new ideas. Kern and Howlett (2009) define policy mixes as "complex arrangements of multiple goals and means which, in many cases, have developed incrementally over many years". These may include rules, economic incentives, voluntary agreements, capacity building, public awareness campaigns, market-based techniques, or any combination of those mentioned above. The right combination of policies can help create an environment more conducive to the innovation and preservation of biological diversity. Existing policy mix studies have a limited reach and use vague language, which makes it hard to analyze policy mixes and their effects. Rogge and Reichardt (2016) warn that the existing policy mix studies have a limited reach and use vague language, which makes it hard to analyze policy mixes and their effects. They mention some of the negative consequences: the limited scope of policy mix concepts may prevent researchers from missing important policy mix parts or processes in their analyses. This could make it hard to understand how policy mixes affect sustainability transitions, leading to policy suggestions that need to be more specific and complex about redirecting and speeding up technological change. Additionally, the lack of a standard language could lead to unclear results and make it hard to evaluate, compare, and combine policy mix analyses.

2.3.4 Degrowth and Bricolage Theories

Degrowth emerged in the early 2000s as an academic and activist critique of our dominant socio-economic system which pursues growth at all costs, causing human exploitation and environmental destruction. It stimulates a search for alternatives and pushes us to imagine and practice forms of society and economy that do not need to endlessly grow to merely survive. Degrowth prioritizes social and ecological well-being instead of corporate profits, over-production, and excess consumption, and implies a shift in societal values towards care, solidarity, and autonomy. While, in spatial practices, it remains an abstract concept requiring further work (de Castro Mazzaro et al. 2023), degrowth principle can be found in the realm of open-source (technological) production, particularly in moves towards convivial and appropriate technologies (Ilitch 1973; Vetter 2018). The connection with this specific mode of technology production reflects the notion of "tinkering" involved in bricolage. Furthermore, degrowth has been recently discussed in connection to biodiversity in the policy context, questioning the support for growth in biodiversity and sustainability policies and the inadequate attention paid to the question of how growth can be decoupled from biodiversity loss (Otero et al. 2021). The relationships with contextual specificities and local knowledge involved in the notion of bricolage are well reflected in the discussion of the resilience of family farms by Darnhofer et al. (2106):

"Bricolage is an on-going process, where heterogeneous objects and concepts are combined, where ideas are tinkered with until something is created that the farmer believes will work for a particular project at a particular moment. But in this process, the farmer

also explores new ways of framing the situation and probes combinations of potential actions which may yield qualitatively new options. It is about seeing new possible relations between elements. Often, the 'bricoleur' does not have a clear end in sight, but rather a vaguely defined project, which is itself subject to change depending on what is available and what is seen as promising" (ibidem: 117). The word "bricolage" is derived from the French verb bricoleur ("to tinker") and the English term DIY ("Do-it-yourself") is the closest equivalent of the contemporary French usage. Typically, it refers to the construction or creation of a work from a diverse range of things that happen to be available.

Bricolage theories are used in various fields, e.g., anthropology, psychology, philosophy, education. Examples include the concept of "social bricolage," introduced by cultural anthropologist Claude Lévi-Strauss in 1962 in his book *La Pensée sauvage* ("The Savage Mind", 1966 translation). Lévi-Strauss was interested in how societies create novel solutions by using resources that already exist in the collective social consciousness. In his book, he uses the term "bricolage" to describe the process that leads to the creation of mythical thought. This process is seen to be opposed to the engineers' creative thinking, which proceeds from goals to means. Mythical thought, according to Lévi-Strauss, attempts to re-use available materials (concepts, objects) in order to solve new problems. Furthermore, Gilles Deleuze and Félix Guattari, in their 1972 book *Anti-Oedipus* (1984 translation), identify bricolage as the characteristic mode of production of the "schizophrenic producer", thus positioning this concept as part of their critique to capitalist production. In education, bricolage is seen to learn and solve problems by trying, testing, playing around, contrary to the analytical style of solving problems. Extended to research, the term bricolage refers to the use of multiple research methods and theoretical traditions, to reflect the complexity of knowledge production and the interrelated complexity of both researcher positionality and phenomena in the world (e.g., Kincheloe and Berry 2004).

The notion of bricolage reflects an approach to finding innovative solutions, which are specific to a context and result out of experimentation with what is locally available (materials as well as thoughts, concepts, cultural and political characteristics of a context). The experimentation involved in bricolage does not have a clear, well-established goal, but rather a vaguely defined project, which is itself subject to change depending on what is available and what is seen as promising (Darnhofer et al. 2016). This is different from the rational reasoning and outcome-oriented perspective on other forms of experimentation intended at finding innovative solutions, like living labs, while the process of bricolage helps prodding the imagination on what is "thinkable", contributing to framing and re-framing the problem at hand, and thus the solution. Furthermore, the need to work within the existing "repertoire" (or knowledges, materials, tools) positions bricolage as a form of innovation reflecting sufficiency and flourishing with what exists, rather than creating "new" things that may require new resources, as well as being remote from contextual specificities of where the solution is needed.

The notion of bricolage could be used as a conceptual-methodological lens to investigate how local communities care for biodiversity in various forms (e.g., for soil, in the case of Foodpark Amsterdam case). The concept could allow exploring possibilities for anchoring transformations to sustainability in terms of biodiversity in collective action as a potential move away from planned efforts by governing bodies to regulate and thus control the use of land.

However, instead of strengthening theories of "path dependence" in innovation analysis, Martinez calls for an idea of "path creation". Path creation brings into play "not only the social and institutional processes inherent in path dependence, but more importantly, the socio-cognitive processes of enactment that are involved in the creation of new states" (Garud and Karnoe 2001: 7, in Martínez 2017). As the author states, "the way in which innovation was treated until recently in biology was closely related to the adaptive function of a trait considered novel" (ibidem). But this approach tends to dismiss the importance of understanding the deep causes beyond the emergence of a specific variation and tends to exclude other kinds of innovation not visible in a precise function. This is why the evolutionary concept of "exaptation" - instead of adaptation - emerged in biology, "according to which, novelties may have originated for reasons unrelated to their present

function" (ibidem). In this respect, the link between biology and culture\society might be refreshed in original ways, that means by paying more attention to "deep ontologies of social processes, as opposed to the traditional tendency to construct models of technological change based on flat ontologies that lead to modeling innovation as an aggregative phenomenon" (ibidem).

2.3.5 Synthesis

The table above summarizes the main conclusions regarding the approaches examined.

Table 6 – Macro level theories for the analysis of nature positive/biodiversity innovations

Theory	Method Adopted	Key assumptions	Key variables	Strenghts	Weaknesses
National or Regional Innovation Systems (NIS/RIS)	Longitudinal quantitative analysis or historical documental analysis	National/Regional specialization of innovation depends on a plurality of actors and institutions involved	-RandD expenditure -Educational system and human capital available -Collaborative networks. -Presence of Local Collective Completion Goods -incubation activities -funding and support services for innovation -public administration efficiency	-Suitable for comparative analysis - openness to the combination of analytical methods - the robust presence of classifications of national innovation systems to read the different contexts in a diachronic and longitudinal way. - considered both a theoretical concept and a policy tool	- Mainly created to explain the processes of economic innovation. - overestimating path dependence mechanisms and not for the recognition of more grassroots processes of change - a critical perspective on capitalism is missing
System Theories	Qualitative analysis	Communications systems in various societal systems that correspond with high impact sectors and see how bio-innovations lead to contingencies and ambivalences, revealing also explicit or hidden power structures	-Cultural, linguistic and discursive issues	- focus on discursive and communicative dimension related to innovation -considering hidden structure of power	-risk of relativism
Sustainable Transition Theory	Mixed Methods	Governance and guidance of the transition play a crucial role in mobilizing different institutional levels and a plurality of	-Policy Mixes - Instruments for Innovation -Multi-level perspective	-Multidimensional and multiscale analysis -Focused more on co-creative process	-Difficulty to evaluate all the relevant dimensions and to compare or combine different level of analysis

		material and immaterial resources	-Transition Management	-Considering the role of niche innovation	
Degrowth and Bricolage Theories	Qualitative and Action Research Methods	Based on the critic of Growth Capitalist Paradigm, exploring possibilities for anchoring transformations in collective action move away from planned efforts by governing bodies	-Bricolage / thinkering practices	-Multidisciplinary approach -focused on open (source) tech - Focus on path creation instead of path dependance	-Undervaluing the scale and impact of innovation -incapacity to look at the transformation from experiments to policies -underestimating the role of institutional environment

3 Cases of innovation and transformative change

3.1 Introduction

In this section are examined several micro-cases of innovation for biodiversity. Nearly all the cases discussed here are characterized by four main dimensions: self-emerging, unplanned, more-than-human, disruptive. Furthermore, all of them fall within the four BIOTraCes domains: (a) Maritime/aquatic living sources; (b) Forestry; (c) Agriculture and food production/consumption (d) Urbanization. A further area, which we called Sustainable Tourism (e) was introduced by one of the cases here presented.

Each of these cases allows us to reflect on several issues that are relevant for the BIOTraCes project and for the 9 case studies conducted by the different project teams and recalled for convenience at the end of this section. First, the ambivalence in the relationship between success and failure, too often discussed in a dichotomous/antithetical way (best versus bad practices). Outclassing this approach, the cases discussed in this section try to identify how failure and success are "entangled" or intersect each other, with reciprocal mechanisms of shadowing or enlightening. Secondly, we reflect on the interstitial and frictional dimensions in the proposed experiences for highlighting ambiguities, contradictions and unexpected results with respect to what innovation for biodiversity means (technical or complex and multidimensional variables; static and dynamic dimensions, agreements and disagreements, consents and dissents zones are crucial here). Lastly, for each case, we try to indicate which methods – among the ones listed in WP1 Action Research Guide – have been adopted and with what results/difficulties or problems.

Not all of these cases relate directly to biodiversity conservation processes, but all of them are good examples of practices and policies that contribute at least indirectly.

Before describing each case in detail, it may be useful to dwell on a problematic aspect whose recognition can guide the work on case studies. In 2021, the website Climate Change exhibited its top 10 innovations in nature and biodiversity. Many of the selected cases do not have any connection with local groups, inhabitants, or civil society at large, and it is not clear what impact they might have at a societal level. Only few of them, seem to have a direct link with local groups and institutions, and try to take into consideration the co-production of innovation through the direct involvement of the population. This is an initial fact that the case studies of BIOTraCes must take into account. Biodiversity innovation is almost identified with technological interventions that provide "smart"

solutions without any exchange with the people involved, and without a clear understanding of social sustainability. Only for one of the latter the link between innovation and society is evident, i.e., "Living Shorelines". In this project,

"Various coastal communities in the USA are taking a hands-on approach to tackle coastal erosion, a process now exacerbated by strengthening storms and rising sea levels. Instead of relying on bulkheads and expensive seawalls, communities are building living shorelines. In an effort to slow the encroaching coasts, volunteers bring in vast quantities of oyster shells onto awaiting rowboats, that are distributed along the shoreline and strategically placed in shallow water. The innovative idea consists of 20-foot-long artificial reefs, containing over 200 bags of oyster shells placed along these marshes. With the help of the non-profit Choctawhatchee Basin Alliance (CBA), these living shorelines along Florida's panhandle represent a sustainable, cost-effective alternative to seawalls that are traditionally built of concrete, wood and hardened plastic".

The approach shown by this experience seems to have much in common with that adopted by the BIOTraCes project.

The cases discussed below contain many points of reference regarding the human-nature relationship. A deeper analysis of these initiatives has identified several remarkable elements. These include emotions, knowledge, willingness to sacrifice and recognition, time and space, as well as the manner of mutual connection and a kind of institutional freedom. These characteristics are part of human-nature mechanisms. At their core, they consist of giving meaning to changes in both nature and society, and to the emotions, affects, moral attitudes they evoke. All kinds of inner contradictions can also arise, because not every expression of what groups or individuals frame as "nature" is equally valued. Based on that meaning and emotions, a perspective is coloured on problems surrounding nature conservation and, for example, dealing with "newcomers to nature". Such a perspective could, for example, imply that nature suffers greatly from plastic pollution and that it is therefore necessary to clean up litter. Such a perspective contains a combination of ideology and one's own vision on action, and often goes against prevailing views. For example, someone can be very happy with moles in their garden, because they improve the soil with their digging. His neighbours will not appreciate this, and protecting moles is very exceptional anyway. And this is also where local knowledge comes into play, because a new perspective on a problem also requires the development of new knowledge. This knowledge is necessary to determine what someone can do to give space or protect nature, but also to convince other people. The emotions and associated vision, knowledge and actions form the mechanism of social connection. Based on what people think should be done, relationships are entered into with (potentially) like-minded people. This may also involve institutions with which one wishes to collaborate.

The following graph (During et al. 2022) provides a simplified idea of the mechanisms of "nature positivity", based on the two cases mentioned above.

Fig. 6 Mechanisms in nature positive society
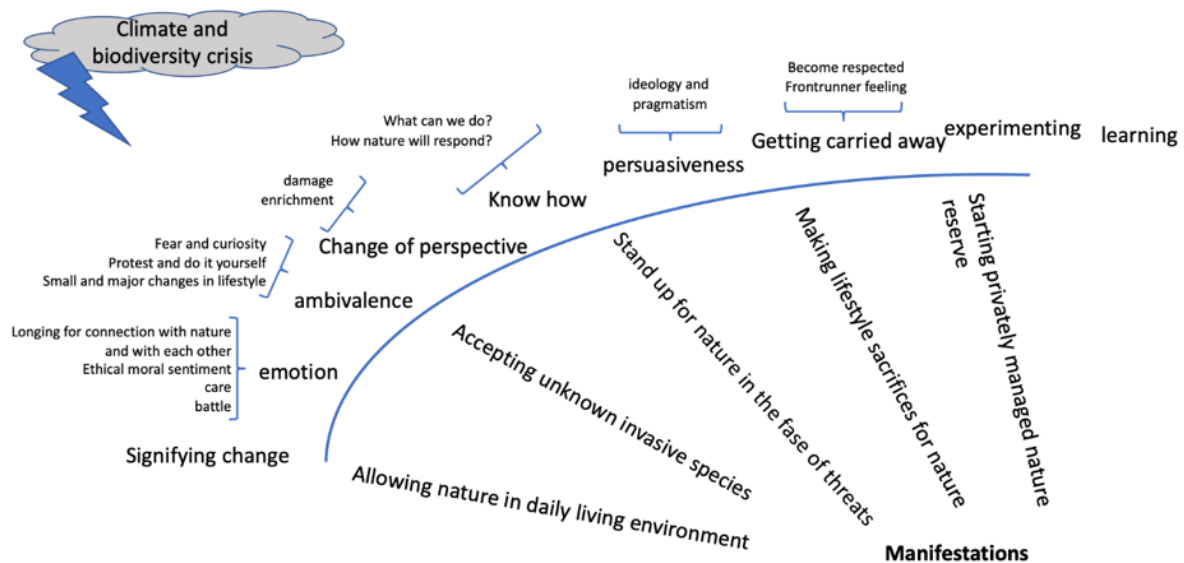
Source: our elaboration

Many of the cases we present shed some light on the mechanisms of a nature positive society. They show deep ambivalences in human-nature relations and how these can be sources of disagreement or even conflict.

3.1.1 Maritime/aquatic living sources

Oostvaardersplassen, The Netherlands

A provocative effort to rewild and de-domesticate landscape and its nonhuman inhabitants was made at the Oostvaardersplassen in the Netherlands. Information about this case can be found in a paper by Jamie Lorimer and Clemens Driessen (2013). The authors don't use the term innovation, but it is implicit in their reasoning. They define "wild experiments" those interventions that cannot make recourse to the ontological concept of Nature: "These experiments – they argue – involve open-ended, uncertain and political negotiations between people and wildlife. They occur in inhabited places and involve multiple forms of expertise, not all of which are human". The meaning of experiment is not positivistic, thus. Wild experiments are based on "hybrid fora" in which various forms of expertise come together to deliberate knowledge production and application, "some of which are human, some of which require tuning into the diverse becomings of nonhuman forms and processes" (ibidem). The notion of "wild" here does not refer to any anti-modern wilderness. These experiments for instance might take place in post-industrial "urban wilds".

The categories used for this 1.5 report are all there: self-emerging, unplanned, more-than-human, disruptive. Interventions indeed remain open to "the emergence or 'likely presence' of nonhuman 'wild things'" (ibidem). In addition, transformations tend to be self-emergent, and not rationalistic: the interventions are not planned by experts charged with conserving biodiversity and ensuring biodiversity control. They are "surprising ecological events" that do not result from "a tendency towards the imposition of forms of transcendent order that often have poor ecological (and sometimes social) consequences" (ibidem). They do not derive from what the authors call "government by experiment" (ibidem). "Operating as open-ended, learning processes", "without a Nature to protect and a Science to unequivocally define its properties and mark its boundaries, real-world experiments risk becoming aligned with the interests of the powerful" (ibidem). In this sense they are also disruptive.

Below a table where Jamie Lorimer and Clemens Driessen (2013) summarize the main differences between traditional biodiversity experiments and what they call wild experiments.

Fig. 7 -Key Properties of two models of an environmental science experiment

	Experiment	Wild experiments
Ontology	Transcendent order of Nature and Society	Immanent and indeterminate world of humans and nonhumans
Epistemology	Hypothetico-deductive method	Designed to generate surprises
Politics	Delegative: science creates facts, politics decides what matters	Dialogical: emergent collectives for generating and deliberating knowledge
Location	Laboratory (and occasionally the field)	The 'wild'

Source: Lorimer and Driessen (2023)

Their definition of biodiversity innovation as a "wild experiment" has to do with co-learning by surprise and generating emergent knowledge, which are indeed crucial factors in BIOTraCes project.

To discuss this approach, Lorimer and Driessework reflect on the already mentioned case study conducted at Oostvaardersplassen (https://rewilding.org/european-experiments-in-rewilding-oostvaardersplassen/), frequently cited as highly exemplar of the movement of "rewilding" in Europe: a publicly owned polder just north of Amsterdam in the Netherlands:

"Reclaimed from the sea in 1968, this land was initially designated for industrial development. This did not occur, and the site was abandoned and colonized by greylag geese, whose grazing behaviour prevented forest succession and created ideal habitat for a range of rare and migratory bird species" (ibidem).

This area passes through several transformations then. Herds of horses and cattle were introduced in the zone to diversify the 'naturalistic grazing' performed by the geese, then red deer that gradually create "ecologies that are claimed to be analogous with Europe at the end of the Pleistocene" (ibidem). It was a very controversial case, however, in the Netherlands, and also the object of a public inquiry. Was this wild experiment artificial or authentic? Can it be considered a success? For whom? Or is this experiment a dramatic failure?

Many problematic questions were raised on this experiment, and, in certain circuits, it became a sort of failure model: "revealing purported paradoxes that undermine its found or made status" (ibidem). For example, "commentators sympathetic to the farming and hunting lobby dwell on fences and flood control, arguing that the artificiality of OVP undermines its authenticity" (ibidem). Controversies arose also on the welfare of animals, when food became scarce, and some animals started to die of starvation.

However, taking it as an inspirational example from the Platform Wild Europe (a "success" story), defenders emphasized the processes "which they argue serves to highlight rewilding as a concept that does not aim at the fixed conservation of particular species, habitats or a priori lost landscapes, but rather opens for the continuous and spontaneous creation of habitats and spaces for species' (Rewilding Europe 2012b)" (ibidem).

What is tricky in this case is precisely the ambivalent relation between success and failure. The latter are so entangled, with reciprocal mechanisms of shadowing or enlightening, that it is difficult to unravel their wires. Moreover, the experiment raises a problem of responsibility: who is responsible and for whom? Haraway's (2008) cosmo-politics of "response-ability" stresses that there are different things at stake in processes of rewilding like this one: human groups with both different interests and values (public officials, scientists, birdwatchers, farmers, animal welfare campaigners, rangers and wildlife associations, institutions, ecologists, even the law, etc.), individual animals/plants, the

species they represent and the wider ecology they help compose. It seems evident that the best interests of all these do not always align.

The conclusions from this case are interesting, too. As the authors say, "environments cast off from a fixed Nature and operating in the wild outside of the laboratory (or equivalent computer models) are inherently political" (ibidem). BIOTraCes can benefit from the knowledge gained from a case like this, so as to avoid producing a neutralized (standardised?) portrait of a homogeneous "community" participating in protection of biodiversity.

Rural Portugal

This is a case on psychosocial historiography of key large-scale hydroelectric power plants in Portugal. Secondary sources include archival footage from journalistic pieces, public documents and grey literature on hydropower in Portugal, the book and newspaper articles. Primary sources include narrative interviews with participants in the movement.

In rural Portugal hydropower development left a legacy of neglect and inequality, transcending different political periods. It began during the dictatorship and continued into the democratic era, driven by a colonialist mindset. Local communities' needs and concerns were often ignored as the push for industrial progress continued relentlessly. Local authorities and influential businesses promoted the construction of hydropower dams, promising benefits like improved living conditions and reduced reliance on fossil fuels. In reality, these promises didn't come true. The communities faced unsafe working conditions during dam construction (toxic materials used, falls from the construction site), disruption to their way of life, harm to the environment, displacement and uncertainty about their future. The expected benefits from these dams largely failed to materialize. In essence, Portugal's hydroelectric power policies appeared as a form of energy colonialism, with large hydropower projects generating capitalist gains based on local communities' exploitation. The concept of renewable energy colonialism helped uncover the underlying issues, showing not just immediate harm but also prolonged neglect across different political regimes. This was often concealed behind talk of progress and economic growth. Grassroots movements like Terra de Miranda gave communities a voice and addressed some of their concerns. The story of hydropower development in Portugal reminds of the resilience of communities in fighting for a fairer future in the face of systemic injustices.

This case of hydropower development in rural Portugal serves as a source of inspiration for future cases dealing with similar issues. It underscores the enduring impact of neglect and inequality that can persist across different political eras. This case highlights the need to scrutinize promises made by authorities and influential corporations, which often prioritize industrial progress over local communities' well-being. Moreover, the concept of renewable energy colonialism, as applied in this case, provides a powerful analytical tool to uncover systemic issues beyond immediate harm. It reveals the prolonged neglect and injustice that can be hidden behind the veneer of progress and economic growth. Crucially, the case illustrates the potential for grassroots movements like Terra de Miranda to give voice to marginalized communities and address their concerns. It serves as a testament to the resilience of communities in the face of systemic injustices, inspiring future cases to advocate for a fairer and more equitable future.

When we reflect on this case, we can indeed observe the relevance of these interstitial and frictional dimensions. The interstitial dimensions are evident in the spaces between different stages of hydropower development. For instance, the gap between the promises of improved living conditions and the actual experiences of communities highlights an interstitial space where the reality deviates from the expectations. The interstitial dimension can be seen in the transition from the initial lack of recognition of Indigenous rights to the later acknowledgment by the Supreme Court. These in-between spaces reveal important insights into the complexities of the processes. The frictional dimensions are particularly apparent in both cases.

Groundwater sustainability

A relevant contribution about transformations to groundwater sustainability is offered by Zwartevee et al. (2021) in *Transformations to groundwater sustainability: from individuals and pumps to communities and aquifers*. In this article, the discussion is conducted through an ethnographic analysis of diverse cases of community-based initiatives and engagements with groundwater (e.g., in India, Algeria, Morocco, Tanzania, Chile, Peru, USA, Zimbabwe, Syria). The initiatives used as examples consist of people who self-organise, in some cases with outside support, to capture, share, re-charge or protect groundwater in places where threats of depletion and/or pollution are particularly acute. They involve the development of new groundwater imaginaries, based on alternative ways of organising society-water relations. Examples include creative ways of knowing groundwater, for instance: 'water towers' that young farmers in Algeria use to establish whether or not they can irrigate; participatory groundwater assessment and recharge methods developed by ACWADAM in Maharashtra; 'pozas' used by mango farmers on the desert coast of Peru to assess and deal with water scarcity and fluctuating availabilities; and embodied ways of knowing in Ghana, serving as a useful tool for understanding groundwater governance for irrigation during the dry season. The notion of 'bricolage' (or tinkering) offers a useful conceptual-methodological lens to investigate groundwater governance arrangements in various contexts and illuminate how practices of using and governing water often involve a patchworking of technologies, knowledges and institutions.

The examples discussed in this article might inspire BIOTraCes Wp2 implementation by discussing the notion of bricolage as mode of innovation, which is context- and need-specific.

- Experimentation as involved in the notion of bricolage implies that success and failure are interrelated, as innovation happen through trying, learning by doing, re-framing problems, and tinkering with ideas and materials until an appropriate solution is found.
- The cases do not specifically engage with innovation for biodiversity, as innovating takes a holistic approach to addressing an issue that is found in a specific context at a specific moment in time, as identified by a specific community, which by its nature involves biodiversity. Main conflicts could arise between top-down government efforts to regulate and control what are environmentally damaging practices (e.g., water extraction) and bottom-up efforts of communities to take care for the resource (e.g., aquifers on which they depend for their livelihoods and income, as discussed in Zwarteveen et al. 2021). Moreover, conflicts could also arise in terms of the values guiding innovation, e.g., economic growth vs. community well-being and resilience.
- Bricolage can take the dimension of a methodological lens, as illustrated by Darnhofer et al. 2016. In the example discussed, farmers' experiments are seen as a speculative method of knowing, of working with uncertainty, not only limited to their material dimension but also feeding the imagination on different ways of farming. As such, bricolage, or tinkering with what is readily available (knowledge as well as material objects and contextual circumstances) can become a method *per se*. This could be more structured when combined with design approaches, for instance inspired by architectural design, as discussed in Baibarac-Duignan and Medesan 2023.

Coastal human-nature relationships, Okayama, Japan

The study by Uehara et al. (2020) explores the role of relational values in the Satoumi. Satoumi refers to a centuries-old Japanese stewardship practice and envisions a kind of

human-coastal relationships that is beneficial to both, biodiversity stewardship as much as human practices. Satoumi can be circumscribed as Japanese coastal socio-ecological production landscapes. The researchers asked three questions:

- how critical are relational values for communities involved in creating Satoumi?
- How does ocean literacy thought in high schools contribute to cultivating relational values in students?What is residents' willingness to support continuation of ocean literacy as a measure for cultivating relational values?

Cultural context of study emphasizes the community aspect of nature stewardship, that is, communities are made through nature. Taking care of the ocean and coastal areas is part of the local culture. This is why early environmental education programmes on ocean literacy, are widespread in the area. However,despite the cultural importance of the coastal landscape, authors state that stewardship is declining in the region, and less and less young people engage in socio-natural practices. Enhancing existing relational values could hence lead to a stronger connection of young people with their environment.

Stewardship activities involve eelgrass bed restorations, oyster harvsting and fishinig. The community aspect, amongst fishers, and between fishers and nature. However, there are less and less fisher working and contributing to maintain Satoumi in the region. Thisis why, the region started an ocean literacy program at High Schools to educate local pupils about the practice. Researchers applied a multi-method approach: a survey with 472 households to explore the importance of relational values, interviews and participant observations with students of ocean literacy program, and contingent valuation method to measure residents' support for ocean literacy programs.

They found that students' participation in the ocean literacy program increased relational values, as students developed a stronger connection with nature the longer, they participated in the program. This also contributes to a stronger willingness to participate in stewardship programs and connected the younger generation to older fishers.

3.1.2 Forestry

<u>Gothenburg, Sweden</u>

In a literature review of forest ecosystem service innovations in Europe, Maier et. al (2021) describe how governance innovations in forestry is often tied to some degree to public support, financial or in kind. Most innovations based on entrepreneurial or personal engagement within the forestry sector itself can be found in market-oriented provisioning forest ecosystem services such as timber or charcoal production, with the goal to increase the economic feasibility of forest production. Innovations or payment schemes relating to cultural ecosystem services are often initiated from outside forestry, for example within the tourism sector, and regenerative ecosystem service innovations (including for biodiversity) are instead most often supported by governments or public authorities where the production goals are less important (see also Mann et al. 2022). For the individual forest owner, the link between governance innovation, forest management and ecosystem service provision often rest on voluntarism and in the end the personal engagement of the forest owner.

About 50% of Swedish forests are owned by private owners. This is a very heterogeneous group, and only to a varying degree do these forest owners actively engage in forest management. In many cases, forest management is contracted to larger organizations with strong ties to the forest industry. Considering the above dimensions from previous research, the question is thus to what degree private forest owners have the practical capacity and personal engagement to commit to other forms of forest management and different innovative governance frameworks. One important aspect of the UGOT case is thus to analyse how forest owners reflect on these dimensions, disclosing what kind of arrangements would be necessary to initiate a positive change for biodiversity in privately owned Swedish forests.

A particularly interesting situation characterizes one of the case study areas on the island of Hisingen north of Gothenburg. The city of Gothenburg owns about 11000 hectares of forest, of which 6000 hectares are protected due to especially high natural, cultural or recreational values. That the protected forest is used with high biodiversity is not something innovative, but the rest 5000 hectares are unprotected and seen as a "reserve forest" for the future expansion of the city. The land was bought for precisely this purpose in the 1960s. Instead, the "innovation" here is that the city intends to use this forest for producing high natural, cultural and recreational values in the meantime, and not as a classic production forest intended for the forest industry. The forest policy of the city of Gothenburg does not at all prioritize production value. Instead, they want to promote older trees, leave some areas unmanaged, increase the deadwood volumes, promote forest grazing and protect key biotopes. And they want to combine this with ambitious recreational goals, such as well-kept paths, better accessibility, visual diversity and recreational facilities. Forest management is intended to be dominated by continuous cover forestry, and they want a larger proportion of older, larger trees, primarily broad-leaf trees. However, the important question for BIOTraCes project is whether this innovative initiative from the City's side will have an effect also on the adjacent privately owned forests. In interviews and workshops, this will be more fully analysed from UGOT.

The examples illustrated above clearly show the lack of efficient grassroots initiatives for biodiversity when it comes to European forestry. The example from the forest policy in Gothenburg remains an interesting case, especially about the analysis of individual forest owners' reactions to this development. We expect to find variations in the ways these forest owners use their forests, inasmuch as the case in question is located in an urban region where it is likely that forest owners' livelihoods depend on forestry only to a limited degree.

A further interesting dimension of the Gothenburg case is that the area was dominated by largely bare hills and heathland up until the turn of the 20th century. This means that the forests that now stand on this land are comparatively young, and that previous biodiversity related to the heath and hills landscape has been slowly eroding away the last hundred years. Since the goal of the city is to create a more developed forest landscape, it is interesting to note that there is little reflection on what values that will further disappear through this initiative.

The case itself will most likely not be possible to categorise as either a failure or a success story since the biodiversity, cultural and other ecological values that are produced through this forest regime most likely are high solid. The problematic aspect is that, while values embedded in preexisting landscapes are bound to disappear, some of them are integrally interwoven with species and beings of the past which is still part of those very landscapes existing today.

Another interesting aspect of this is that the forest that the city of Gothenburg now wants to use for this purpose, was once planted for the intention of timber production. This also points to the importance of understanding the historical dimension of these types of initiatives. With new city governments, new directions from the state or changes in the surrounding world, it is not unlikely that the function fulfilled by the forest will change once again. Were it possible to also include adjacent private forest owners as part of this initiative, it would be more likely that it would last longer.

Relational values of forests

In this case, the relational values frame is applied as an innovative tool to better explain local communities' motivations in nature stewardship. The global loss of forests is negatively impacting Indigenous Peoples and local communities (IPLCs) who depend on them for their livelihoods. To halt forest loss, different approaches such as market-based approaches (e.g., payments for ecosystem services) or rights-based approaches have been developed. These approaches, however, have often not resulted in reductions in deforestation and improvements in livelihoods. Furthermore, incentive-based activities are often rejected, while voluntary action often surfaces without the need for imposing

incentives. This calls for a better way of understanding how local communities value nature and what drives motivation for participation and proactive conservation.

The study looks at communities in two villages in Sulawesi, Indonesia. The communities voluntarily maintain local forests but have shown rejection towards formal forestry programmes promoted by external actors. The relational values concept is applied to explain the values and motivations of community members. Data was collected through semi-structured interviews, narrative walks, gender-differentiated focus group discussions and participant observations.

The results show that the local communities value their forests based on relational values such as identity, ancestral heritage, sense of place and spiritual values. Narrow economic or conservation values at the heart of incentive-based approaches can exclude or conflict with local communities' understandings and motivations to protect nature. Actors from outside these communities therefore need to adapt programs to the local context and pay more attention to relational values.

Success could be here interpreted as a research reflection on own positionality in respect to local believes and world systems:

"At the beginning of the conversations, we observed that questions using the term 'values' (e.g., 'what are the values of the forest for you') would be answered only with products used by the people (e.g., water and pangi fruit), which could be interpreted as instrumental values. To examine whether a thing was replaceable, we posed the question 'what would happen if [the thing] is gone?' The local NGO partner also informed the research team that people were worried of being labelled mystical or superstitious if they spoke about traditional beliefs to outsiders. Thus, we began this study with trust building approaches, spending more time in the villages, accompanied by the NGO members who had become well known and well-liked by local people."

They have found both individual-forest, individual-community and community–forest relations, that build also upon more-than-human approaches as spiritual values about nature play a central role.

3.1.3 Agriculture and food production/consumption

Júba Wajiín, Mexico

The main focus of this case is, more precisely, the sidelining of local indigenous communities and the violation of their rights to their land which results in disruption of indigenous agriculture practices and ways of life as well as biodiversity loss. Júba Wajiín stands as a village nestled within a remote, hilly landscape within what is today known as Guerrero, in rural Mexico. This area has a rich history of housing the Me'phaa community, who have strenuously opposed various forms of displacement and loss of their land throughout the precolonial, colonial and postcolonial eras. Employing collaborative and participatory approaches, this tight-knit community successfully initiated and triumphed in a protracted legal struggle, which currently poses a formidable challenge to the practices of extractive mining. During the period spanning from 2001 to 2012, the Mexican government granted substantial mining concessions to mining firms. In mid-2013, the residents of Júba Wajiín made a surprising discovery: without previous communication or consent, their land had been designated for mining exploration, with these rights being awarded to the British-based mining company Horschild Mexico. In response, they resorted to the support of human rights activists who successfully used participatory action research to raise awareness and mount a legal campaign. Tlachinollan, a regional human rights organization, conducted legal counselling workshops and held meetings with local officials and community leaders during this process. At first, the courts dismissed the lawsuit, arguing that residents couldn't be recognized as Indigenous due to their adherence to Catholicism and their use of the Spanish language. In response, a media outlet called La Sandia Digital assisted the community in collectively recording their blend of religious and spiritual customs, their proficiency in the Mhe'paa language, and their longstanding

agricultural use of the land. This effort resulted in the creation of a documentary film titled "Juba Wajiin: Resistencia en la Montaña," which served as visual legal evidence to support their case. Following their victory at the district court level, they proceeded to bring the case to the Supreme Court, requesting a thorough examination of the legality and legitimacy of the mining permits. Horschild, alongside other mining corporations, ceased their opposition to the case, resulting in withdrawal of permits. The overarching issue concerning the territorial rights of Indigenous peoples remained at the core of a legal debate until mid-2022 when the Supreme Court made a significant ruling. It established that Indigenous communities possessed a constitutional entitlement to be consulted prior to any mining operations within their land. While this marked a victory, it was a partial one. The term 'consultations' frequently becomes subject to manipulation by governmental and corporate interests, especially in cases involving marginalized communities. Júba Wajiín's tactics demonstrated success, but the ongoing fight against displacement and land dispossession remains an ongoing challenge.

The case of Júba Wajiín offers inspiration for future cases involving Indigenous communities and territorial rights. It highlights the importance of community resilience and determination in resisting displacement and land loss throughout historical periods. The successful use of collaborative and participatory approaches, supported by human rights activists and media documentation, showcases the power of grassroots efforts in raising awareness and initiating legal battles. Furthermore, the case's journey from the district court to the Supreme Court and the nullification of mining concessions underscores the potential for legal avenues to rectify injustices against Indigenous communities. However, the recognition of Indigenous consultation rights by the Supreme Court also emphasizes the ongoing challenges arising from state agencies and private players attempts to manipulate such consultations. Future cases can draw inspiration from Júba Wajiín's strategies while also recognizing the need for continued vigilance and advocacy in the fight against displacement and land dispossession faced by Indigenous communities.

It's indeed crucial to overcome the simplistic dichotomy of best versus bad practices and explore better how these two concepts are interconnected. In this case, as in the case of Rural Portugal, we can clearly see the fragility of success attained by grassroots initiatives. This fragility is magnified by the inherent resource limitations that grassroots initiatives and communities often face when pitted against entrenched vested interests. Maintaining the status quo becomes an ongoing struggle, as political and business organizations continuously pursue their own agendas. In fact, they often deploy counter-efforts to undermine the progress achieved by communities. However, it's important to recognize that persistent and coordinated efforts can lead to enduring changes. One key aspect of this transformation lies in shifting mindsets and values within society. When communities and grassroots initiatives tirelessly advocate for their causes, they not only promote change but also work to transform the broader perception and values held by people. This change in perspective can, over time, foster a more supportive environment for a sustainable enduring success. In essence, success and failure in the realm of grassroots initiatives are intertwined, with each casting light on the other's vulnerabilities and strengths. It's a dynamic process where the struggles and setbacks faced by communities can ultimately lead to lasting positive changes when coupled with determination and a shift in societal values.

In this case, the tension between the promises of progress and the detrimental effects on communities and the environment creates friction. As in the case focusing on rural Portugal, the legal battle against mining companies and the manipulation of Indigenous consultations by corporate interests represent frictional elements. These conflicts and disagreements are central to understanding the challenges faced in the pursuit of justice and environmental protection.

The analysis of interstitial and frictional dimensions in cases of hydropower development, as well as of Indigenous resistance to mining can be readily extrapolated to cases involving river dam removal (Lithuania case), where communities may oppose removal primarily due to aesthetic reasons or emotional attachment to the dam but may not fully grasp the ecological consequences which might and will, in the long run, extend to the wellbeing of

local communities. In the context of river dam removal, the interstitial dimension would involve the transition from aesthetic considerations to ecological awareness. Initially, communities may oppose dam removal due to their appreciation for the aesthetics of the dammed river or emotional attachment. However, this interstitial space can be used to educate and inform communities about the ecological benefits of dam removal and the potential restoration of natural river ecosystems. Also, just as in the previous cases, there may be gaps in discerning between aesthetic value of the dam and the ecological consequences of its existence. These knowledge gaps could potentially be addressed through engagement and awareness-building efforts.

To add, river dams might become an important part of people's identities. This would require space for exploration to deepen the understanding on how river dams are intertwined with people's identities and exploring the historical formation of these identities is crucial when addressing knowledge gaps related to biodiversity loss. It requires a nuanced approach that acknowledges the significance of the dam in people's lives while also providing space for exploration about the ecological impact. By recognizing and respecting these deep-rooted connections, it becomes possible to foster a more informed and collaborative dialogue surrounding river dam removal and its ecological implications.

Frictional dimensions in dam removal cases can manifest as conflicts between communities who prioritize aesthetics and environmentalists or conservationists advocating for dam removal due to biodiversity concerns. These tensions highlight the need for exploration to uncover the plurality of views. Friction may also arise from a lack of awareness or neglect of biodiversity loss. Communities may not fully understand the impact of dams on aquatic ecosystems, including the disruption of fish migration, alteration of habitats and changes in water quality. This friction underscores the importance of fostering a holistic understanding of the ecological consequences.

In extrapolating this analysis to river dam removal cases, the key takeaway is the necessity of bridging the gap between aesthetic values and ecological awareness. Communities opposing dam removal for aesthetic reasons can be engaged through exploration efforts that highlight the broader ecological benefits, including habitat restoration, improved water quality and support for aquatic biodiversity. Furthermore, addressing the frictional dimensions through open dialogues and collaboration between community members, environmentalists and relevant stakeholders could be yet another way. This collaborative approach can help reconcile differing perspectives, ultimately leading to informed decisions that balance aesthetic preferences with the ecological well-being of river ecosystems.

"Nutrire Trento", Italy

Another relevant project that concerns the Agriculture and Food sector is called "Nutrire Trento" in Italy. In the Italian region of Trentino, fruit growing is the main activity and the production of apples represents 82% of this economic activity. The current almost monoculture agricultural landscape (vine/apple tree) is a relatively recent fact, dating back to late 1960s.

"Nutrire Trento" project aims to encourage the development of the local food system in urban environment as key places in densely populated territories, favouring the transition to a more sustainable and varied type of food supply.

The project started in 2017 as part of UniCittà, a Memorandum of Understanding and a Joint Action Program between the Municipality and the University of Trento with the aim of improving and promoting the relationship between the local actors of the local food system and the city food supply. The driving idea is the attempt to relaunch sustainable urban and peri-urban agriculture, facilitating direct contact between producers and consumers, enhancing short supply chains and direct sales bringing the city closer to the countryside through food.

The project objectives included the following main activities: increase citizens' information and awareness of production and on sustainable consumption also through the involvement

of associations of consumers; promote studies and research on young people's lifestyles and consumption and adults and on short supply chains; plan activities with schools, with interventions aimed at canteens e food education involving pupils and parents; activate and/or technical and commercial training courses for agricultural producers; develop logistics solutions to facilitate access to local products and reduce costs for small producers to support their income.

The project appears to be of great interest not only because it deals with an area of action of the BIOTraCes project but is interesting for the objectives and for the participatory methods adopted (Living Lab and collaborative mapping). Another interesting element of the project is the centrality of the University in the network and the collaborations with other EU research project (FOOdIVERSE; FoodWave). Therefore, the research dimension is another qualifying element of this experience.

"Nutrire Trento" is a network of networks, similar to a food council, but it is informal and it does not have a physical headquarter. Monthly or bi-monthly meetings are held at the municipality, at the university, or online. The network received 20,000 EUR as seed money in the first four years of operation, as a joint contribution from the university and the municipality. Other resources derived indirectly from different European projects on circular economy and sustainability. Nutrire Trento influenced the agenda setting of the municipality and it was included in the electoral agenda of the mayor, who was elected in May 2020.

The coordinator of Nutrire Trento comes from the municipality and he is constantly in contact with other Italian cities who are experimenting similar activities, collaborating and exchanging experiences.

Nutrire Trento adopted an open innovation ecosystem approach trying to get a plural composition in the table of coordination and among the activities promoted within the Lab.

The main collaboration between FOOdIVERSE project and Nutrire Trento was formalized in May 2022, designating that Nutrire Trento was officially the living lab of the project. More specifically, the agreement established: (i) joint actions to promote citizenship participation, environmental and social sustainability; (ii) research and knowledge transfer, human resources, training and cultural offer, communication.

Nutrire Trento operates locally, intending the local dimension as the Trento municipality, although producers come from the entire Trentino province. It has 227 members, although participation in the meetings is variable (approximately 20-30 people per meeting in the last year). They are mainly academics, local administration members, short supply chain networks, farmers, consumer groups, representatives of local associations. Among them, consumers belong to the middle class, while producers are more differentiated, mainly professionals and public servants. Decision making is implemented by a deliberative approach. The main concern of those involved in the project was sinc the beginning to find ways to involve larger and more diversified sectors of society.

The project idea of generating an "extended peer communities" which have different values, priorities, interests and capacity of action have an impact on the regularity of the presence at the meetings and on the level of engagement in the different activities. The major part of the projects are carried out by the academic or municipal partner, while synergies with many of the associations involved remain limited. Moreover, the role/ of researchers deal with power asymmetries, not only as foreign "experts", but also for their role of initiators/facilitators of the living lab process. Most importantly, it is observed tensions between the participatory/deliberative character of the table and the institutional environment: the latter is not formally hostile towards dialogue (it is one of the promoters of the table) but lacks capacity in terms of implementing strategies and keeping the dialogue alive. Moreover, there was a detachment between the deliberative space of the living lab, which made it possible to get the Municipal Council (legislative power) approve crucial deliberations, while the local executive power completely ignored them so far. While a deliberation on local food policy was proposed by three joint commissions and approved by the municipal council in September, the executive bodies did not act accordingly.

3.1.4 Urbanization

Zwolle, The Netherlands

This case is about greening the city in the city of Zwolle. Small 'green' projects are being carried out in many cities and villages. People who want to do something for nature do not always limit themselves to nature. For example, they also want a healthier, more inclusive or more sustainable living environment. Their focus varies, but this always involves combining nature, social and/or sustainability goals, which can reinforce each other. This is described below for the Assendorp district in Zwolle. In 2017, contaminated soil was excavated in Seringenstraat in this district. The residents of that street and the municipality used this excavation to jointly turn the street into a healthier living environment that is also more climate resistant. Facade gardens and green roofs, rain barrels and water fences were installed in the street. The 2015 sustainability agenda of the municipality of Zwolle states that Zwolle has the ambition to increasingly meet its own needs. The 2018 Zwolle Heat Guide and the Zwolle Adaptation Strategy report that Zwolle has the ambition to be a natural gas-free and energy neutral city by 2050. The changes in Seringenstraat that responded to these ambitions also inspired other streets in the district. This is how Climate Active Assendorp was born. In the same period, groups of residents also started installing solar panels and insulating houses. Together with the Zwolle energy cooperative Blauwvinger Energie, a start was made to tackle the neighbourhood collectively to make the houses more sustainable. All together this became '50 shades of green Assendorp'.

The growth process that led to 50 shades of green Assendorp starts with one of the residents of Seringenstraat. He and other neighbours had been talking to the municipality for some time about a solution for the contaminated soil behind his house. The subject of climate change keeps him busy, and he believes that "when looking for solutions you should also try to look for it within yourself". Initially, the residents worked on greening Seringenstraat with facade gardens and green roofs, and on water storage through rain barrels and water fences. This inspires neighbours and acquaintances. More streets participate, now under the name 'Climate adaptive Assendorp'. In addition to facade gardens, parking spaces are being sacrificed here and there for greenery and to plant trees. More activities are also being taken up, people are installing solar panels, insulating their homes and helping each other with this. The initiative is growing further through collaboration with the Zwolle energy cooperative Blauwvinger Energie, the energy counter Improve and Save, Buurkracht, the municipality, a project developer, the digital neighbourhood newspaper and Windesheim University of Applied Sciences. The municipality, province and Drents Overijsselse Delta Water Board (also) provide financial support.

Streets that participate work with street ambassadors who serve as a point of contact and who help introduce new actions and coordinate activities. Sustainability becomes part of everyday life through information evenings, brainstorming sessions, living room games or the mutual exchange of information about energy saving. The steps taken to get greener in the neighbourhood vary from a plant instead of a paving stone, facade gardens, planting trees, green roofs and planters, to, for example, transform an organic vegetable garden within the monastery walls of the Dominican monastery, which is now maintained by twelve families. In 2017, one of the street ambassadors created facade gardens and planters together with neighbours and was surprised at how easy it was: "It turned out not to be complicated at all"... "I coordinated with four neighbours and started a neighbourhood app. The municipality provided a container with soil. The people themselves provided the plants. On the day itself, everyone took a role. In no time we had a street with facade gardens."

People experiment and gain knowledge and experience themselves, then help and complement each other. One of the residents is an urban planner at the municipality of Zwolle and co-author of the Zwolle Adaptation Strategy. He knows that Assendorp will be about five degrees warmer than the outskirts of Zwolle and decides to install a green roof on his shed. A neighbour and gardener have been experimenting with green roofs for a year and is helping with the construction. Another neighbour and garden designer puts

together a flower mixture consisting of plants that occur in the IJssel-Vecht delta. In addition to better insulation and cooling, the aim is to contribute to an ecological corridor through Zwolle. The owner of the roof hopes "soon to enjoy a beautiful flower meadow and the buzz of butterflies and bees." Sedum roofs or grass roofs are constructed, but preferably a green roof with flowers that occur naturally in the area, because their ecological value is greater. The list of measures that the district is taking is even longer, but it is clear that a whole social process is underway here. A far-reaching measure is that several streets are temporarily closed to cars and are designated as residential streets. This also applies to their own cars. Parking elsewhere is the motto. We see this as the beginning of a more sustainable and nature-inclusive style of living in this increasingly greener neighbourhood.

The positive energy in this example grows with every new development that is implemented. People learn and become more and more involved and enthusiastic. People inevitably invest a lot of time in 50 Shades of Green. According to the state of affairs on the website (October 20, 2020), 25 houses have been better insulated, 20 roofs have solar panels and 13,124 m2 of green roofs have been installed. In addition to time, money has also been invested in this. Exchanging information about energy savings, sustainability, climate neutrality, a liveable neighbourhood and making homes more comfortable have become part of daily life in the neighbourhood. Tackling many different projects and topics seems to work well in Assendorp. It is possible that people who differ from each other can better find their own way to become active. The projects reinforce each other. The desire to have more natural green in the street means that people are willing to park further away. A survey by the municipality shows that approximately half of the people who complete the survey (response was 58%) are willing to do so. This stimulates the approach to green mobility. There is a clear connection between greener streets and roofs, and the projects that revolve around water storage. People were also open to innovative ideas such as the water wall. The entire approach to communication is creative: not only through information evenings and brainstorming sessions, or the mutual exchange of information about energy savings, but also through the housewarming game (living room conversation). Creativity can also be seen in the experiments with the temporary living street, or temporary planters. Knowledge is either in-house or has been acquired yourself. One of the initiators of the whole from Seringenstraat has retrained himself as a gardener after his experiments with green roofs. He, a garden designer and a philosopher meet in Seringenstraat. The retrained gardener sets up a network company with green professionals, Stadshovenier Zwolle, which focuses exclusively on Zwolle because they find connection important.

The maybe most important revenue of this swarm of projects and initiatives is that young people use the website to share ideas on buying without packaging material and other ideas to live in a more sustainable manner.

In this case there are strong elements of ambivalence. Improving the green in the city may involve the unintended introduction of foreign exotic plants. Ecologists have strong feelings against such initiatives. Here they try to solve it by using a regional plant composition. Another element of ambition is that for many people the streets don't match their ideas of how a tidy neat city street should look like: without weeds! This is entangled with their ambivalent attitude towards nature, as being beautiful and dangerous at the same time.

In various ways this case is relevant for BIOTraCes. There is a rather insignificant leverage point, the construction work in the Seringstraat. It would be better to speak of a leverage process in this case, because the inhabitants of Assendorp went on an itinerary to a better living environment, closer to nature. Moreover, one can see that re-relating to nature has not been the initial intention of the citizens. It became an obvious side goal after initial working on climate adaptation and energy projects.

This case was not analysed with one of the methods from the action research guide. The overall picture was taken from internet sources, after which several interviews were done to collect information on how barriers were seen and overcome.

Botanical sidewalk chalk, the Netherlands

An important case in about natural gardening, that is, citizens that turn their garden into a nature reserve. Recently, a French initiative called 'Botanical sidewalk chalk' spread to the Netherlands, drawing attention to weeds that spontaneously appear between paving stones: nature in miniature, directly in the neighbourhood, and spontaneous. Anyone can encounter them, sidewalk plants. Roadsides and dikes are increasingly growing herb-rich vegetation. Enthusiasts have been paying attention to wild plants for a long time, but not necessarily in their own environment. There is interest in naming it; taking photographs; finding and utilizing edible or medicinal wild plants. An online group focusing on 'useful' edible wild plants, started in 2012, has no less than 42,341 members. Focused on your own environment, even very close to your own garden, are online groups such as Gardening with wild plants (started in 2015) and Natural gardening. Weeds receive positive attention in many ways. There is a 'weed maker', a 'dandelion day', there are workshops on using nettles, and, for example, an artist collective that focuses on new perspectives on weeds.

The term 'weeds' is used for plants that are not wanted, or not wanted in that location. 'Weeds do not exist' is used by people who want to argue against that. Not only people who like a 'neat' garden and do not want to encounter wild plants that just blow in, but also nature conservationists who do not want invasive exotic plants, are bothered by 'weeds'. The trend towards petrification of private gardens shows that for some people even every plant can be a weed. New-build areas in particular are relatively stony. The Steenbreek Foundation (committed to greening ....: stone out, plant in), has experienced that when the first residents of a new neighbourhood create a green garden, this is followed by these first residents laying stones in the garden, which imitation and the neighbourhood ultimately becomes much grittier. In the context in which the Steenbreek Foundation operates, where a cautious approach helps to replace a stone with greenery, a discussion about which greenery, wild native plants versus non-native plants, is too complex.

Garden reserves, an initiative of the radio programme Vroege Vogels (Early Birds) that was inspired by a French idea from 2011, tried to take steps in this regard. They specifically targeted garden owners and promoted more natural gardening. This initiative also leaves room for taking both large and small steps: "A garden reserve does not have to be a messy, disorderly collection place of all kinds of plants that you actually don't want [.........] If your garden has seven out of ten criteria, then your garden is eligible for the garden reserve stamp". The criteria include a recommendation to use native plants, but also to have "junk corners and branch walls".

The natural gardens can contain serious contributions to biodiversity. There are many examples of garden owners who count the number of species in their garden, which regularly exceeds a thousand. By planting regional plants that have disappeared, the insects that are connected by their life cycle to them may return. On a regular basis new discoveries are made wherein extinct insects are re-discovered in natural garden. This often is being noticed in the media, functioning as a reward for the garden owner and an incentive for those who wish to nurture nature but have no idea how to do this.

Acculturation through nature, Canada

The study by Ono et al. (2020) focuses on migrant women's outdoor experiences and perspectives in their host country in the metropolitan Vancouver area, Canada. Focusing on 27 recent female newcomers, in order to understand how new migrants' engagement with their host country's natural environments affects their lives, behaviours, and identities post-migration. The authors conducted multi-lingual interviews with female vulnerable migrants covering a broad age range and places of origin such as Syria, China, Iran, Iraq, Colombia, Eritrea, Honduras and Afghanistan. 26 of the 27 respondents spend time in nature at least on a weekly basis, half of the sample daily.

The authors found that half of the study participants engaged in new outdoor activities, they have not practiced in their home countries. Nature and related activities in nature

hence offered a space of acculturation to the new cultural context. Half of the participants also reported to engage in similar activities as in their home countries, which helped them to maintain an emotional bond to their culture of origin. Further, the research shows that outdoor activities are an important way to socialize and create social bonds. Nature has been reported to be a contribution by: enhancing physical and mental well-being, offering an escape from stressful home environments, provide mechanisms for self-care and socializing, enhance well-being of children, empowerment and creation of sense of belonging. That is, the strengthening of relational values about nature and with other humans through nature played an important role in female newcomers' arrival and settling in a new cultural and social context. This reiterates the call for intersectional and plural approaches to understand the importance of nature for intersecting identities and bodies.

The study focuses specifically on perceptions of female migrants and mothers with findings stating the importance of psychological and non-material connections with the natural environment. The study, however, focuses on individual relationships with nature and less on the impacts on forming and deepening communities. Study success could be framed around its research focus on traditionally marginalized and vulnerable communities and by applying an intersectional approach.

Athens, Greece / London, UK: the urbanization of nature

The classification of the case studies proposed in BioTraces project (Urbanization, Agriculture and food production, Maritime/aquatic living sources, Forestry etc.) remains a useful tool, but the risk of a compartmentalized analysis can be mitigated by the use of an UPE approach, that considers the interdependencies between the ecological and the urban. This suggests that many of the cases could be read under the lens of what has been called the "urbanization of nature: [that is the process through which "all types of nature are socially mobilized, economically incorporated (commodified), and physically metabolized/transformed in order to support the [continuous] urbanization process" (Swyngedouw and Kaika 2014: 462)].

Many recent analyses inspired by Urban Political Ecology (UPE) can be found in Kaika et al. (2023). A much older book (Kaika 2005) offers an example of how an UPE approach can be used in the analysis of a concrete case. In this book the author argues that the modern cityscape can be viewed as a "palimpsest landscape" of hybridity, incorporating the dynamic interaction between nature, technology, and humanity. The discussion focuses on the urbanization of water supply in two cities with vastly different paths to modernity – Athens and London – analysing the relationship between public utility, privatization, and water cost and availability. Water is examined considering the "Promethean project" of modernity – the taming of nature that began with the process of industrialization, rendering nature useful for humanity, emancipating humankind from nature, and protecting the city from the caprice of the elements. The author's central argument here is that the product – commodified water – has become alienated from the consumer to the extent that, save for restrictions placed upon usage as mentioned above, there is no cognitive connection made between nature and the city (Riley 2006: 130).

3.1.5 Sustainable tourism

Transylvania, Romania: The road that unites.

Via Transilvanica ("The road that unites") is an example of a case of innovation. It is a long-distance hiking trail that spans across Transylvania and not only. It is a project to promote outdoor recreation, cultural heritage, and sustainable tourism in the region. While Via Transilvanica does not explicitly focus on biodiversity conservation, it indirectly contributes to the conservation and appreciation of Transylvania's natural and cultural landscapes. Via Transilvanica can contribute to the transition towards more sustainable tourism practices in Transylvania. Promoting low-impact outdoor activities and encouraging visitors to engage with local communities and natural environments supports

the development of a sustainable tourism sector that values biodiversity and cultural heritage. Via Transilvanica connects diverse stakeholders, including hikers, local communities, and tourism operators. It provides opportunities for collaboration and co-management of resources along the trail. This fosters a sense of ownership and shared responsibility for the protection and sustainable use of natural and cultural assets. While not directly addressing ecosystem services, Via Transilvanica showcases the value of Transylvania's landscapes and natural areas. It highlights the recreational and aesthetic benefits that can be derived from intact ecosystems, encouraging visitors to appreciate and support the preservation of biodiversity and ecosystem integrity. Finally, the development of Via Transilvanica involved collaboration with local communities, tourism organizations, and other stakeholders.

While certain parts of the Via Transilvanica might have emerged informally due to local hiking activities or shepherd paths, large-scale long-distance trails typically require planning and coordination by authorities and organizations to create a consistent and accessible route.

In a long-distance trail like the Via Transilvanica, more-than-human implies combining environmental considerations, conservation efforts, and sustainable practices to minimize the impact on the surrounding ecosystems and wildlife.

Via Transilvanica can inspire BIOTraCes implementation as a model that like other examples (El Camino) influenced cultures, formed communities, and contributed to the development of the areas they crossed. Today, Via Transilvanica does the same. It offers hikers a route that will stretch for 1400 km at the end of the development, and it helps more than one might think in the development and promotion of the communities it passes through (Gruia 2021).

As a long-distance trail that goes through different landscapes and ecosystems, the Via Transilvanica is a place where various players and interests meet. This space can make it hard for environmentalists, local communities, government agencies, and tourist operators to work together. As to biodiversity along the trail, innovation means, for example, figuring out how to deal with complicated and multidimensional factors. To have the least effect on biodiversity, technical things like designing trails and building facilities need to consider ecological factors. As the trail changes over time, the dynamic aspects come into play. This entails that adaptive management methods must be used to deal with new challenges and changing ecological conditions (Appelbaum et al. 2012; Kotter 1996). Moreover, agreements and disagreements emerge when stakeholders with different perspectives and values collaborate or clash in decision-making processes. Finding a balance between conservation efforts and tourism development requires careful negotiation and compromises. Via Transilvanica can become a place to talk about the ambiguities and contradictions that come with innovation for biodiversity. It can be used as a case study to help parties have productive conversations and find sustainable solutions that consider how hard it is to keep the environment safe while also growing the economy.

Tourist testimony highlighting tourists-community interaction: "I knew that the people who do tourism in the village are the same people who make the food, and the accounting and the interior design, and clean the rooms, and they also have to go to the animals or make hay for them. A guy I met one evening at a table, at a guesthouse, came up with suggestions for the host."

Tourist testimony highlights the multifaced ViaTransilvanica: "Some people have already told me that they think that the 1,400 kilometres of Via could at least become a business card through which you can get to know a less-seen part. You, the hiker, have this road that unites (Via's slogan) all the differences: religion, architecture, gastronomy, traditions, and people's way of being. This is also the hope of the team that through a long-term hike, you can better understand other worlds with which you do not interact in your routine. At the same time, I also felt that you give the brain room, especially after the 100-kilometer mark, where you have already tricked your body with a new walking routine, to bring all its concentration to an immediate present. A present where, beyond the welcome revelations and the demons left in the woods, you might think about nothing, a moment I

longed for as well. When it came, it was with guilt that I wasn't thinking deeply about anything, that it "should" be like that, then it was with release."

Tourist testimony highlighting the natural beauty of Via Transilvanica: "The forests on the route are among the most beautiful gifts of Via. In the forest, you shout, whistle, sing and stop to admire the points of light on the ground that penetrate between the branches. In the forest, you have time and space to think about nothing. Time to breathe."

Future mapping can be used to describe a possible future positive situation of the communities on Via Transilvanica (Mento et al. 1999; Phillips 1996). The exercise should involve members of these communities. These steps would be followed (Mento et al. 1999; Phillips 1996): 1) imagine a compelling future as if it was happening already for a selected situation, such as having an average of N tourists per season who spend at least 3 nights in their villages; participants should imagine and discuss what are the impacts of Via Transilvanica on their community and place (economic, social, cultural, and environmental), who benefits and who doesn't, who should benefit and who is left out, what are the good consequences and the negative ones, how can the former be enhanced and the latter avoided, what are the possible conflicts and how they can be managed; 2) mapping out milestone events and achievements that must happen to reach that future point; participants should indicate who must be involved, who is likely to participate and who is not; what are the necessary support/corrective measures, etc; 3) managing accomplishment of the imagined outcomes in the present; participants should imagine.

Similar mapping or scenario exercises can be done for other situations, including conflicts.

3.1.6 Synthesis

Table 7 – Case study of Biodiversity Innovations and their relations with BIOTraCes Cases

Case	Area/Country	BIOTraCes domain	Main Targets	BIOTraCes case studies with similar features / objectives
OOstvaarderplassen	*The Netherlands*	Maritime/aquatic living sources	Rewilding and de-domesticating a polder landscape and its non-human inhabitants	Case 5. Social opportunities in ecological recovery
Rural Portugal	Portugal	Maritime/aquatic living sources	Psychosocial historiography of key large-scale hydroelectric power plants in Portugal	Case 8. Citizens based alliance for proactive ecological recovery Case 2. Mértola Future Lab
Groundwater sustainability	Several countries	Maritime/aquatic living sources	Community-based and self-organized initiatives and engagements to protect groundwater in places where threats of depletion and/or pollution are	Case 5. Social opportunities in ecological recovery Case 8. Citizens based alliance for proactive ecological recovery

			particularly acute	
Coastal human-nature relationship	Satoumi, Japan	Maritime/aquatic living sources	Cultivating relational values and sustaining socio-ecological production landscapes through ocean literacy	Case 5. Social opportunities in ecological recovery Case 7. Herders' knowledge
Gothenburg	Sweden	Forestry	Avoiding market-oriented provisioning forest ecosystem services	Case 6. Holistic place-based forest views Case 7. Herders' knowledge
Relational values of forests	Sulawesi, Indonesia	Forestry	Relational values frame applied as an innovative tool to better explain local communities' motivations in nature stewardship	Case 4. High Nature Value Farming Case 6. Holistic place-based forest views
Juba Wajiìn	Mexico	Agriculture and food production/consumption	Employing collaborative and participatory approaches to address legal struggles, in order to challenge the practices of extractive mining	Case 1. Foodpark against industry Case 2. Mértola Future Lab Case 4. High Nature Value Farming
Nutrire Trento	*Italy*	Agriculture and food production/consumption	Encouraging development of local and sustainable food system in urban environment as key places in densely populated territories	Case 1. Foodpark against industry Case 2. Mértola Future Lab
Zwolle	*The Netherlands*	Urbanization	Small 'green' projects carried out by citizens in cities and villages	Case 1. Foodpark against industry Case 3. Urban Schoolyards-Biodiversity Lab
Botanical sidewalk chalk	*The Netherlands*	Urbanization	Natural gardening; citizens turning their	Case 3. Urban Schoolyards-Biodiversity Lab

			garden into a nature reserve	Case 9. Ecovillages as hotspots of biodiversity
Acculturation throw nature	Canada	Urbanization	New migrants' engagement with their host country's natural environments (and how this affects their lives)	Case 1. Foodpark against industry
The urbanization of nature	*Athens (Greece) London (UK)*	Urbanization	Analyzing the relationship between public utility, privatization, and water cost and availability	Case 3. Urban Schoolyards-Biodiversity Lab Case 9. Ecovillages as hotspots of biodiversity
The road that units	*Transylvania, Romania*	Sustainable tourism	Promoting outdoor recreation, cultural heritage, and sustainable tourism	Case 8. Citizens based alliance for proactive ecological recovery Case 7. Herders' knowledge

4 From experimentation to policy

4.1 Introduction

The relation between innovative practices and policies has been effectively analysed and or experimented in several theoretical approaches. It allows us to reflect on interesting transactions/transfers between innovative practices emerged on the ground and the policy level, in both directions: from innovative experimentations to polices, and from policies to new innovative practices.

4.1.1 System theory and adaptive governance

Ideas on governance can be embedded in system theory. A transition to a nature positive society would require adaptive governance. The latter is about building in flexibility, in organizing and managing. It may involve small changes, a major transformation or doing nothing at all, depending on the scale in space and time, the task and the adaptability. Prescribing a single prescription for survival or nature positivism is problematic. It is important not to fall into rigid concepts that can only be applied in one way. For example, if a community is only organized in one singular way (think of fishing dependence, for example), it is vulnerable to external changes. A complementary and competitive way of organizing makes a community less vulnerable and more flexible, because more diversity in organizations and institutions benefits resilience. The question then is to understand why it is very difficult for some organizations to change and not for others. This is related to the adaptive capacity of the administration and the policy. Immutability is usually the result of certain types of knowledge that do not enter into an institution. Openness to local

knowledge is important for adapting to local circumstances. There is also a lot of local knowledge regarding dealing with nature, which is stored in cultural traditions and social memory. Policy is not always able or willing to take this into account. However, diversity of perspectives and multilevel governance are very important to build flexibility into policy.

Society never has had a clear idea of what nature is, of its value, and of the value of resilience and adaptability in the natural system. For adaptive policy, it is useful if this diversity of thoughts is also present in the system of administration and policy, the governance system. The government is increasingly becoming the referee between that part of society that wants to offer nature more space and that part that does not want to be bothered by it or is even afraid of it. Other images of nature and its resilience come from other policy levels: the dilemma of unprecedented resilient nature of a nature positive society that also responds to the changing climate, versus nature that is recorded in European agreements and reports.

Support for nature, acceptance of planning, trust in experts, changing views on democracy, in an environment where pressure on space and environmental quality does not diminish, all this contributes to the fact that the resilience of nature is a gift from God, but also that its resilience, or its outcomes, immediately become politicized in a complicated way. The combination of natural and social resilience puts the governance system to the test. On the one hand, that system is burdened with a legacy of rigid thinking about nature and local initiative, and on the other hand, its steering power is affected by the changes mentioned. Social system transformation can also benefit nature, of course, and can sometimes be explicitly aimed at protecting or restoring nature. A nature positive society may be a matter of new players, new arenas, new ideas, and of existing players, both in government and outside, developing new initiatives, or even redefining themselves. There remains the issue of a double contingency: resilience in society to improve the relationship with nature may turn out differently than policy would like (people like to choose their own path) and nature may also respond unexpectedly.

Sentiments of nostalgia, attachment to old species, landscapes, customs, techniques, can be drivers for protection, which leaves room for places, species, processes that can again maintain resilience. But it can also lead to more management, more and more, to keep nature as it is, which must necessarily lead to a decrease in natural resilience, i.e. the self-organizing capacity of ecosystems. It can also lead to a narrowing of the perspective, which blur (the possibilities for) different management of the same place, and also relationships with the spatial context. While this is important for a positive relation with nature. After all, resilience in nature benefits from the exchange of populations, because this maintains genetic diversity. This exchange partly takes place in the human biotope, which is almost all the space outside the nature reserves.

Social system transformation and natural resilience cannot always be reconciled, but their relationship can be refined and adjusted to some extent. Any form of social organization is a form of risk management, including the risks arising from the existence and use of a particular physical environment (Deacon et al. 2018). Ecological resilience, which is good for people in general - since ecosystem collapse is usually a bad thing for us - can, on the other hand, cause great harm to specific forms of human organization. The dependencies of an ecological system are often not understood in social systems, something that proponents of social-ecological perspectives have long emphasized. The same holds for the prefiguration of a nature positive society. This indicates that there are generally opportunities to sharpen observation, within social systems, of the functioning of social and ecological systems, their resilience and their mutual dependencies.

In a governance perspective, politics and administration, governance and policy, are always intertwined. It is not about something new, where in the past the government would have made all the decisions, and now citizens come in. Rather, it is about systems of players who contribute to making decisions that are binding for a collective. Sometimes laws carry more weight, in other cases plans and reports. Sometimes civil servants articulate the ideas and politicians sign them, sometimes civil servants routinely elaborate on politicians' decisions. Elsewhere, it is experts or lobbies behind ministries or ministers

who come up with the actual content of a decision and manage to push it through. The fact that there is always governance, that the patterns of participation and representation are always more complex than the formal scheme of decision-making suggests, is already a good start. It suggests a wide range of possibilities for adaptation.

Thanks to the development of governments, with a multitude of actors who participate in governance, there is room for a multitude of goals, power relations, forms of expertise, and perspectives (Duit and Galaz 2008). This complexity makes direct control more difficult, making top-down adaptation to major hazards more difficult. It does make it easier to manage risks in the long term, by allowing more observations and more forms of management, and accepting more different links between forms of understanding and forms of organizing.

If we are concerned about a resilience gap, it seems appropriate to first consider how governance works in practice and not as in the formal self-description of governments and their components. Secondly, whether the existing diversity of perspectives and forms of knowledge address both the natural system and the social system and also the impact of the natural system on society and vice versa. Third, it must be considered whether there are major contradictions between natural and social resilience in current circumstances. An important recommendation concerns reflexivity in the governance system: organizing self-reflection in the governance system can help to understand the adaptability of the governance system itself. This in turn can be considered a prerequisite for a continuous adjustment of observation, and of coordination of natural and social systems. If the operating system does not understand itself and its own adaptability, it is more difficult to determine how it can adapt to changing conditions in the social system or natural system, and how it can thereby solve problems of discordance between social systems and ecological resilience.

The multitude of relationships between social and ecological systems, and between the social system and the governance configuration, ensure that more adjustments are possible than usually thought, but also that the systems are fairly unpredictable for each other. This makes it even more important to strengthen both the observation and coordination of governance, and it indicates that governance must be always adaptive (Capano and Woo 2017). This does not mean that everything must be immediately changeable, that the machinery of governance must be completely renewable in the short term. Certainties and certainty are also important, towards society and towards the players within governance itself. What it does indicate is that decisions about this must be weighed consciously and regularly. In times of new challenges that test the adaptability of people and nature, this should happen more often and be more institutionally anchored. Which, it is worth repeating it, does not mean that everything has to change: the guiding force that can come from a law that cannot be changed immediately (compared to a decision or plan, for example) may be necessary to make an adaptive measure possible, to bind the players who need to be coordinated for this.

The quality of decisions about adaptation that are recorded in such a way for a long term, and thus introduce rigidity again, must meet higher standards than the quality of other decisions made in an environment in which adaptation is central. After all, such longer-term decisions entail greater risk in such an environment. Not only do they pose an immediate risk, the risk of excluded alternatives and fewer opportunities for adaptation for a longer period of time, on this issue. It can also mean that experts and interest groups who are connected to a decision made from a central institution (for example, an interpretation of climate adaptation as a matter of building dikes, may not want to give up their place, even if other excluded perspectives suggest more useful adaptations. In this regard. the philosopher Luhmann (1996) would point here to the danger of de-differentiation, which undermines the adaptive capacity of the administrative system.

We hope to have outlined the importance of adaptive governance for a nature positive society, which require innumerable choices, experiments, repertoires of action, re-relations to nature and more. A rigid governance system could kill the diversity and heterogeneity needed for experimenting our way to nature-positiveness.

4.1.2 Long-term grassroots initiatives

Long-term and community engaging grassroots initiatives are for example raised by Singh et. al (2021) as a potential way to gather more indigenous knowledge for biocultural sustainability which can be leveraged to other areas. Their example comes from Community Knowledge Gardens and Clas Reserve Forests in the Indian Himalayas, and while there are certainly valid points in that engaging local communities have many merits when it comes to the intersection of biodiversity and cultural diversity, the forest owners in Sweden are not part of a coherent group or even not necessarily engaging in practical forest management. An analysis through workshops with forest stakeholders in northern and southern Sweden revealed that most stakeholders had a nuanced picture of past transformative change, emphasizing multiple perspectives on decision-making and the importance of communal values. However, when it came to future transformative change, most stakeholders instead emphasized global strategies and discourses detached from local contexts. The authors point out the importance of understanding how transformative change emerges from context (Priebe et al. 2022). This is likely also related to the fact that processes of change (including the effects of innovations) are much more readily discerned with hindsight. When we can observe the results of past initiatives the complex pattern of cause and effect becomes clearer. However, the perception of the potential for future change is often more constrained with all the choices that are currently at hand, as well as the complex interplay between institutions, goals, and a practice in material reality that needs to be confronted.

Contextualising innovation can help in this regard, not the least from a landscape perspective. Understanding the context of innovations proposed by the stakeholders involved will aid in scrutinizing the potential leverage for transformative change that can be drawn from each case.

4.1.3 Integrated Natural Resource Management (INRM)

The paper by Meine van Noordwijk (2019) looks at the idea of Integrated Natural Resource Management (INRM) to reduce poverty and promote sustainable development, highlighting how innovative practices, institutions, and policies work together. INRM is a whole-systems method that considers the connections between natural resources, ways of living, and human health and happiness. It tries to solve complicated social and environmental problems by combining ecological, social, and economic factors into strategies for managing natural resources.

The paper talks about how important innovation is in INRM, regarding new technologies and new ways of running businesses. These innovations are essential to improve resource efficiency, productivity, and resilience, especially for vulnerable communities that rely on natural resources for their livelihoods. Also, the part that institutions play in helping INRM is brought up. Institutions that work well are important for creating an environment where new ideas can grow. These organizations must be flexible, able to change, and responsive to the needs of local stakeholders. This makes it possible for people to work together and make decisions about managing natural resources sustainably.

The author also says that well-designed rules are essential to the success of INRM projects. Policies should encourage and reward innovative practices, and a good setting should be made for managing natural resources sustainably. To do this, policymakers, researchers, and local communities need to work together to create policies tailored to each place's particular social, economic, and ecological realities.

One focus of the above paper concerns to the Theory of Change (ToC) and the Theory of Place (ToP). In the setting of agricultural and food systems, the study discusses the problems with policy change and policy based on facts. It shows how hard it is to understand policy changes, especially for people trained in a mechanistic cause-effect approach to project planning. Some people worry that current policies may be influenced

by political goals that have already been set instead of being based on real proof. The idea of a ToC is introduced to help research projects match what is happening in the real world and deal with problems caused by climate change. The author also criticizes the ToC for underestimating the role of external involvement and research-based knowledge in driving change while overestimating the role of internal changes in social-ecological systems at the landscape and family levels. van Noordwijk et al. (2015) discussed the relevance of Theories of Place (ToP) as a counterpart to ToC's.

van Noordwijk (2019) argues that innovative practices, institutions, and policies should be used in managing natural resources to help fight poverty and support sustainable development. By taking a holistic approach that includes biological and social factors, INRM can make a big difference in reducing poverty and keeping natural resources safe for future generations.

In the cited paper, there are several examples of interesting exchanges between innovative practices on the ground and the policy level. These exchanges go both ways and here are some examples:

i) From new practices to policies:

> a. Agroecological farming: In some places, small farms may use agroecological farming methods focusing on biodiversity, protecting the soil, and using less chemicals. When these practices improve agricultural productivity, resilience, and sustainability, policymakers can see their promise and use them in agricultural policies. So, policies that support agroecology might include incentives, subsidies, or programs that help farmers build their skills to get more farmers to use it on a bigger scale.

> b. Community-Based Forest Management: Policymakers can see the value of community involvement in natural resource management in places where local communities have managed woods in a way that protects biodiversity and helps people make a living. Creating policies could give community-based methods for managing forests more power and legal recognition. This would give communities more control over forest resources and decision-making.

ii) From policies to innovative practices:

> a. Payment for Ecosystem Services (PES): PES policies that pay landowners or communities to keep ecosystems and the services they provide in good shape can encourage the development of new practices. For example, a PES program that pays farmers to protect riparian areas to keep the water clean could develop new ways to use land and protect it, like agroforestry or buffer strips, that improve ecosystem services and give farmers a way to make money.

> b. Feed-in tariffs for renewable energy: When governments set up feed-in tariffs that promise a fixed price for electricity made from renewable sources, it can encourage the use of new technologies and business models for renewable energy. These policies create a market for green energy, which leads to new ways of making, storing, and distributing energy, like solar power projects owned by the community or microgrid systems.

The interactions between creative practices and policies that are discussed in the paper show that local experimentation and policymaking go hand in hand. Policymakers can learn from and be influenced by successful innovations on the ground. This can lead to the creation of policies that support innovation and make it easier to handle natural resources in a sustainable way. On the other hand, well-designed policies can support and reward new, innovative practices that help reduce poverty, improve people's lives, and protect natural resources.

4.1.4 "Flowering Meadows" agri-environmental measure

The goal of the "Flowering Meadows" agri-environmental measure of Fleury et al. (2015) is to protect biodiversity in agricultural landscapes. The authors look at the technical and value changes that came about when this measure was implemented, focusing on how it helped biodiversity. By enhancing floral diversity and providing suitable habitats for various species, the measure seeks to support pollinators, birds, and other wildlife, ultimately contributing to ecosystem health and resilience. The paper shows that the "Flowering Meadows" measure led to significant changes in how land is managed on a technical level. For example, farmers tried new things, like cutting down on how often they mowed and changing how they used fertilizer to help wildflower fields grow and stay around.

The study evaluates the outcomes of implementing the measure in terms of technical aspects and the values associated with biodiversity conservation. It reveals that the "Flowering Meadows" measure led to significant technical changes in land management practices. Farmers and landowners became more interested in biodiversity conservation as they learned how important wildflower-rich fields are for the environment. This change in values made it easier for farmers, conservationists, and politicians to work together, which in turn led to a more participatory and cooperative way of managing biodiversity in agricultural landscapes.

The paper shows how the "Flowering Meadows" agri-environmental measure protects species. By encouraging technical changes in how land is managed and promoting value changes in favour of biodiversity, the measure is a hopeful way to bring together farming and environmental goals. The study shows how important focused and results-driven agri-environmental measures are for promoting sustainable land use and protecting biodiversity.

Actor-Network Theory (ANT) was used to show the interest and participation (Callon 1986) of a considerable number of human and non-human actors in the implementation of the "Flowering Meadows" agri-environmental measure. ANT enables examining how actor networks are shaped, revealing the connections and intermediaries that unite different actors and how these actors engage and enlist new participants. Initially emerging in science and technology studies, ANT has found extensive application in rural studies (Murdoch, 2000; Woods, 1998) and understanding agri-environmental policies (Kaljonen,2006; Morris, 2004).

Some final remarks regard:

> i.   Innovative experimentations to policies: the success of the "Flowering Meadows" attracted the attention of policymakers. As a result, this innovative practice was integrated into agri-environmental policies. The research and positive outcomes from on-ground experimentations influenced the formulation of policies that encouraged and incentivized farmers to implement the practice of establishing flowering meadows on their lands.

> ii.   As a result of the policy support, farmers have embraced the idea of creating flowering meadows as an agri-environmental measure. They have implemented the practice and experimented with variations and adaptations based on local ecological and agricultural conditions. For example, some farmers may adjust sowing techniques or consider rotational patterns to optimize the benefits for biodiversity.

4.1.5 Multi-Level-Perspective (MLP)

Following a Multi-Level-Perspective (MLP), three entities need to be analysed when looking at the transactions/transfers between innovative experimentations and policies. Firstly, the landscape level, describing exogenous macro-trends of the system developing very slowly and autonomously. Secondly, the regime level, composed of dominant structures (such as policies), actors and practices, which determines the functioning of the system and defends its status quo. Lastly, the niche level, where innovations can develop that deviate and are protected from dominant structures, actors and practices.

In the initial, pre-development stage of a transition, alterations occur in the background, affecting both the landscape and niche levels. These changes face resistance from the established regime. As the transition progresses into the take-off phase, substantial structural changes begin gaining momentum. During this phase, these changes exert increasing pressure on the existing regime, causing it to gradually break down. Subsequently, in the acceleration phase, the structural transformations become more apparent as the old regime structures give way to new ones. Finally, as the transition evolves into the stabilization phase, a new dynamic state of equilibrium is attained. During this phase, a fresh regime has fully taken shape, effectively replacing the previous one (Avelino and Rotmans 2009).

4.1.6 Scenario development

As highlighted by Temper et al 2018, moving from experimentation to policy implementation, let alone to new innovative practices, is not an easy task and may indeed be the interface at which transformation needs to be investigated. Civic initiatives and movements around the world (as also illustrated by the Foodpark Amsterdam case) make visible political struggles, as well as aspirations of communities who aim to inhabit other kinds of worlds than those likely to be shaped by current growth-oriented and technology-centred policies. The frictions between the societal values that are behind such struggles could nevertheless provide the necessary fuel for transformation.

One approach that may offer potential for transformation by engaging with alternative practices and initiatives is scenario development. In the context of biodiversity and sustainability policy, the making of participatory scenario could be well suited to overcome the prevalent growth-focused mindset and allow exploring other policy options and the commitments necessary to get there (Costanza et al. 2017). Related to this, Otero et al (2020) propose that the Convention of Biodiversity Diversity (CBD) and IPBES could act as laboratories where alternative policies are designed, tested, and evaluated through enhanced cooperation between countries, the private sector, and the civil society, with scenario development having a critical role in this process.

This could be complemented with scenario making methodologies that engage with (or through) bricolage with local initiatives that provided glimpses into other potential futures, in which biodiversity takes a central role rather than mere economic growth. A recent experimental workshop held at Luktemeerpolder, the site of struggle for Foodpark Amsterdam, explored future-oriented methods aimed at shifting perspectives and values through taking more-than-human perspectives ("Listening to the Soil: Becoming underground astronauts").

4.1.7 The analysis of regional innovation systems

The analysis model proposed by Cooke (2004: 2006) regards an interesting typology of governance systems focused on services and initiatives put in place to disseminate new knowledge. According to such scholar, this is a core process in innovation systems, based on five variables: 1) the source of the initiative; 2) the source of the financing; 3) research skills; 4) the degree of specialization; 5) the degree of coordination.

By analysing regional governance according to these five dimensions, three ideal types emerge.

The first type – the grassroots system (bottom up) – originates and develops through local initiatives, in an urban or district area. Financial support for innovation is widespread and comes from households, the credit system and local institutions. The innovative stimuli derive from the market, the research skills are scattered and mainly of an application type. The technical specialization is weak and oriented towards solving problems that emerge from the

productive sphere. The degree of coordination with supra-local institutions is low. The system also relies on social capital rooted in informal collaborative networks rather than formalized organizations, even though development agencies and local governments play a central role in supporting innovation. The overall coordination, at the regional level, turns out to be limited.

The second type of governance is the network system. Compared to the previous one, this model is more formalized and integrated. The institutional infrastructure involves various levels of government (local, regional and national) and the financing of innovation derives from agreements involving all relevant actors (banks and financial institutions, businesses and government agencies).

Scientific skills are based on a mixture of theoretical and applied knowledge, which allow both basic, wide-ranging and exploratory research, as well as operational and near-market research, i.e. oriented by the needs of entrepreneurs. The technical-scientific specialization is flexible, since the innovative system receives requests from a heterogeneous plurality of actors, ranging from companies that operate on a global scale to small local businesses. The degree of coordination of the system can be high and tends to involve a large number of actors. It is a model that is not driven exclusively by the market, nor is it planned by the regional government. Rather it configures a reticular type of governance, based on partnerships for innovation, in which vertical relationships of power are accompanied by horizontal relationships of cooperation.

The third type is the centralized system. This governance model receives its impulses mainly from the outside, i.e., from central government policies aimed at promoting innovation. Funding is therefore centralized, and the various interventions are implemented through regionalized public agencies. Coordination and specialization are high, and the technical-scientific skills are both basic and applied, linked to the needs of large public companies or in any case from outside the area.

However, the ideal-typical models proposed by Cooke should not be applied in a static way, since the regions that are analysed can undergo transformations that change their characteristics.

This type of reflections, originally born in the context of studies on «traditional industrial districts» and also applied to «technological districts», could have their relevance in the analysis of innovative processes oriented towards sustainability and biodiversity explaining possible pattern and combination of action in innovation governance.

4.1.8 The Nodal Governance Theory

It emerged in the field of political science and public administration. The theory suggests traditional hierarchical models of governance where authority and decision-making are concentrated at the top of a government or organization could be shifted towards decentralized and networked approach (Burris et al. 2005; Holley and Shearing 2017; Shearing and Froestad 2011; Shearing and Wood 2003). The theory recognizes the complexity of contemporary societal challenges and seeks to harness the collective wisdom and resources of multiple stakeholders to address them effectively.

Nodal Governance Theory emphasizes the decentralization of authority and decision-making. Instead of a top-down, command-and-control approach, decision-making authority is distributed across multiple nodes or points within a given network. These nodes can represent various government agencies, non-governmental organizations (NGOs), private sector entities, civil society groups and individual people. In nodal governance, the government operates as part of a broader network that includes various actors from different sectors. These actors collaborate and interact with each other, often forming partnerships and coalitions to address complex issues and provide public services. The networked structure allows for a more flexible and adaptable response to challenges. Nodal governance encourages the active participation of multiple stakeholders. These stakeholders contribute their expertise, resources and perspectives to the decision-making

process. This inclusivity is seen as a way to enhance the legitimacy and effectiveness of governance. Effective coordination among various nodes is crucial in nodal governance. Rather than relying solely on hierarchical authority, coordination is achieved through negotiation, communication and collaboration among the networked actors. This can be challenging, as it requires building trust and establishing shared goals among diverse stakeholders. Nodal governance is often associated with adaptive governance, where policies and responses are continuously adjusted based on feedback and changing circumstances. This adaptability is seen as a way to address complex, dynamic challenges such as environmental sustainability, public health crises and economic development. Advances in information and communication technology (ICT) have played a significant role in enabling nodal governance. ICT tools facilitate communication and information-sharing among nodes, making it easier to coordinate activities and collect data for evidence-based decision-making. Nodal governance can be observed in various policy areas, such as disaster management, public health, environmental conservation and urban planning. For example, in disaster management, multiple agencies, NGOs and communities collaborate to respond to emergencies and provide relief to affected populations. On the one hand, nodal governance offers advantages in terms of flexibility and inclusivity, on the other hand, however, also faces challenges such as issues related to accountability, power imbalances among stakeholders and the need for effective leadership and coordination mechanisms within the network.

4.1.9 The Grassroots Global Governance Theory

In the following example, we will report how transnational networks, in cases where global agreements fall short, implement global best practices such as Integrated Watershed Management at the local and global levels (Kauffman 2016). These examples will be discussed within the theory of Grassroots Global Governance, which is built upon Nodal Governance Theory. In this example some cases succeeded while others fail. The author suggests that the success of these initiatives relayed on strategies that activate influential grassroots actors capable of adapting global ideas to local conditions (Kauffman 2016). This led to unique local experiments, and successful ones are scaled up globally, challenging existing approaches and reshaping international discourse and strategies. Using Ecuador as an illustrative case, we will show how local experiments influence the global governance landscape and how underscoring the importance of grassroots actions lies in their capability shaping global governance.

The implementation of Integrated Watershed Management reforms across six regions in Ecuador, including Ibarra, El Chaco, Pastaza, Celica, Tungurahua and Zamora, drew inspiration from international policies and their advocates. These reforms were pushed forward by various local stakeholders, including communities, NGOs, farmers and others, who engaged in activities such as protests, establishing stakeholder networks and pressuring resistant local stakeholders to act. It was the complex interactions and interdependencies among local stakeholders, rather than a top-down approach, that generated momentum for the implementation of these reforms for sustainable water management. Due to regional idiosyncrasies, these reforms were met with a varying degree of success in different regions, and in some cases, they failed entirely. Furthermore, regions that reached agreements on the reform differed significantly in terms of the content and form of the reforms, suggesting that regions may have distinct needs, capacities and agendas.

As proposed by the Grassroots Global Governance Theory, as grassroots governance networks expand globally, customs and methods rooted in local contexts spread to the international arena. Within these networks, members advocate for these practices as credible alternatives to existing approaches for addressing global challenges (Kauffman 2016). As an illustrative example, Ecuador's experiences with Integrated Watershed Management reform have also contributed to global discussions on sustainable development and conservation. Successful local experiments and innovations have been shared at international forums, influencing global debates on environmental governance

and introducing customized concepts such as 'sumak kawsay' and 'buen vivir' into the international policy debate as alternatives to neoliberal concepts like 'sustainable development'.

One particular Ecuador's case, the Tungurahua case, was unique in how it blended global Integrated Watershed Management principles with local indigenous norms, particularly the concept of "sumak kawsay" or "buen vivir". This mix of global and local perspectives created a novel governance arrangement that now serves as a model for sustainable development. Tungurahua's innovative local governance system gained recognition and resonated with other Ecuadorian communities and organizations, including national indigenous movements. This led to the incorporation of "buen vivir" into Ecuador's new constitution and national development plan. This shift at the (inter)national level is notable as it challenges traditional neoliberal approaches to sustainable development. Ecuador's experience is altering the global discourse on sustainable development. It provides a concrete alternative to the dominant approach advocated through international conferences like the Rio+20 UN Conference on Sustainable Development. Ecuador's success story is inspiring new international governance structures, such as the Global Alliance for the Rights of Nature, which aims to promote the global application of "buen vivir" and alternative approaches to sustainability. Ecuador's efforts and the success of its National Plan for Buen Vivir have led to changes at the international level. The UN General Assembly now holds annual dialogues dedicated to "living in harmony with nature," aligning with the principles of "buen vivir." This has resulted in annual reports on achieving sustainable development rooted in this concept.

To sum up, the aforementioned examples highlight how experimenting with policies that consider the unique regional characteristics and indigenous communities can result in a mutually beneficial process. Namely, international policies and practices can serve as inspiration for tailored adaptations at the local level and recognition and customized policies and practices can gain recognition from the international community, with certain aspects of these customized policies being integrated into global practices.

4.1.10 Synthesis

The table below summarizes the main conclusions regarding the approaches examined.

Table 8 -Analytical approach to governance and policy implementation for biodiversity innovations

Theoretical approach	Key assumptions
System theory and adaptive governance	This perspective highlights the importance of adaptive governance for a nature positive society, which require innumerable choices, experiments, repertoires of action, re-relations to nature and more. A rigid governance system, in fact, could kill the diversity and heterogeneity needed experiment our way to nature-positiveness.
Long-term grassroots initiatives	Long-term and community engaging grassroots initiatives are seen as a potential way to gather more indigenous knowledge for biocultural sustainability which can be leveraged to other areas, in the conviction that engaging local communities have many merits when it comes to the intersection of biodiversity and cultural diversity.
Integrated Natural Resource Management (INRM)	Aimed at reducing poverty and promote sustainable development, highlighting how innovative practices, institutions, and policies work together, INRM is a whole-systems method that considers the connections between natural resources, ways of living, and human health and happiness. It tries to solve complicated social and environmental problems by combining ecological, social, and economic factors into strategies for managing natural resources.
"Flowering Meadows" agri-environmental measure	Aimed at protecting biodiversity in agricultural landscapes, this measure looks at the technical and value changes that came about when this measure was implemented, focusing on how it helped biodiversity. By enhancing floral diversity and providing suitable habitats for various species, the measure seeks to support pollinators, birds, and other wildlife, ultimately contributing to ecosystem health and resilience.
Multi-Level-Perspective (MLP)	MLP is based on three entities that are useful to analyse transactions/transfers between innovative experimentations and policies: 1) the landscape level, describing exogenous macro-trends of the system developing very slowly and autonomously; 2) the regime level, composed of the dominant structures (such as policies), actors and practices, which determines the functioning of the system and defends its status quo; 3) the niche level, where innovations can develop that deviate and are protected from the dominant structures, actors and practices.
Scenario development	In the context of biodiversity and sustainability policy, participatory scenario making could be well suited to overcome the prevalent growth-focused mindset and allow exploring other policy options and the commitments necessary to get there.
The analysis of regional innovation systems	Governance systems focused on services and initiatives put in place to disseminate new knowledge. According to such scholar, this is a core process in innovation systems, based on five variables: 1) the source of the initiative; 2) the source of the financing; 3) research skills; 4) the degree of specialization; 5) the degree of coordination.
The Nodal Governance Theory	Emerged in the field of political science and public administration, the theory suggests traditional hierarchical models of governance where authority and decision-making are concentrated at the top of a government or organization could be shifted towards decentralized and networked approach.
The Grassroots Global Governance Theory	As grassroots governance networks expand globally, customs and methods rooted in local contexts spread to the international arena. Within these networks, members advocate for these practices as credible alternatives to existing approaches for addressing global challenges.

5 Conclusion

This review on the concept of innovation in biodiversity transformative change shows a plural status and different meanings and dimensions at stake in the literature. It is also evident how over time the environmental dimension seems to have been eclipsed or marginalized by more technical or economic visions or conceptualizations. The most recent orientation towards the concept of "social innovation" or "sustainable innovation" tries to interpret the intersections between social, cultural and environmental dimensions, as also recognized by various international institutions and organizations. However, it is still urgent and necessary to better reflect on a conceptualization more consistent with the theoretical and methodological objectives of the BIOTraCes project. In conclusion, we must take seriously this understanding of the environmental and social embedding of innovation in BIOTraCes, giving relevance to contexts and processes more than solutions and products. With this consideration as a backdrop, in our project we may propose diverse attempts of definition of innovation for biodiversity in the direction of a more inclusive/just and nature-positive society. We enlist here some prodromic attempts of definition that could represent a starting point that has to be tested, finetuned and refined throughout the project.

"*Transformative biodiversity innovations are collective, pluralistic processes or self-emergent approaches to inhabiting the lived-inn world that simultaneously meet a social need (more equally and inclusively than existing methods) and lead to improving human-nature relations, and thus to a less harmful use of Planet resources. In other words, innovation is both good for enhancing society's capacity to transform without leaving any living being behind, and good for the environment, enhancing its capacity to flourish through cultivating mutually enriching relationships and empowerment attitudes*".

"*Transformative biodiversity innovation is the process of creating new and better ways of doing things that are beneficial for both human society and natural environment. It involves new collective processes, approaches, cross-disciplinary collaboration, and feedback mechanisms that simultaneously meet a social need (more equally and equitable than existing methods) and lead to improving more-than-human relationships, promoting the sustainable use of natural resources. In other words, innovation is good for enhancing the resilience and diversity of socio-natural systems. It is also good for enhancing more-than human capacity to foster positive transformation without leaving any living being behind*".

"*Transformative biodiversity innovations are social innovations that bring along deep change both in society and in nature. They are transformative because they bring a system over the edge of a tipping point, causing fundamental change in the interactions of its components. Innovations with deep leverage points can involve the epistemic re-embedding of humans in nature, the challenging of the morality of a social practice or knowledge system (e.g., decolonizing) and the incorporation of nature in social identities. When ecological and social resilience re-enforce each other, a significant contribution to a nature positive society may result. We can identify different categories that bring along the deepest levels of leverage: 1) Epistemic innovations (paradigm shifts on how societal groups define their relationship with nature/planet earth); 2) Moral dispositions (how they justify their actions; how they judge moral issues in society); 3) Conceptual innovations (how they conceptualize nature and what knowledge is used to understand the embedding of their actions in nature and society)*".

In taking into consideration these initial attempts, several concerns emerged among BIOTraCes participants:

1. Transformative practices are always embedded within complex systems and structures so even if we question their "morality", without system change it might be hard to transform it;
2. It is not very clear how definitions mentioning resilience in relation to transformative processes address the question of power and power differentials, as well as the issue of marginalization as a harming strategy of integrating "Others" but only through a process of ascribing a different, less legitimized status;
3. Difficulty and risks in producing an "institutionalized" definition of transformative biodiversity innovation. We need to be able to talk about failed innovations, or innovations that come from outside a set of theoretical frameworks but which impact out in different ways.

According to Lidskog and Waterton (2016) "concepts matter" because they encapsulate implicit understandings about the structure of the natural or social environment, as well as convictions pertaining to both the current situation and the ideal state to which it should aim. Conceptual innovation is a process of developing new ideas or ways of thinking that challenge existing norms, paradigms, and assumptions. It is a concept applied to various fields, from science and technology to business and philosophy (Nersessian and Chandrasekharan 2009; Souto 2015), and has a fundamental role in driving societal and individual growth. Hysing and Lidskog (2021) suggest that conceptual innovations can facilitate transformative change by giving to old concepts new meanings and letting new questions emerging. To understand the changes in the environmental and societal landscape, innovative ideas are formulated, and existing ones receive new interpretations. Issues such as, for example, climate change and microplastics contamination have received increased attention in environmental discourse and public debates nowadays. This is a consequence of the dynamic interplay between environmental transformations, technological and scientific advances, as well as changes in societal behaviors. It is important to note that there is a reciprocal relationship between concepts and changes, where environmental shifts necessitate linguistic adaptations and conceptual improvements. In turn, these conceptual innovations facilitate transformation of the environment (Lidskog and Waterton 2016).

The proposed theoretical frameworks show the difficulty of adopting all-inclusive and comprehensive perspectives for the study of biodiversity-related transformative processes. While considering the usefulness and fertility of the different approaches listed in this report, it is evident that each has strengths but also various limitations in relation to the project objectives. If the micro perspectives emphasize the centrality of individual agents' preferences, values and expectations in respect to specific transformative processes, a focus on the meso dimension better enables us to capture and grasp the spatial, organizational and network aspects that are equally essential in understanding sustainable and biodiversity-oriented innovations. Furthermore, with their inclusive character and large analytical dimensions, macro, holistic theories and approaches can incorporate a plurality of theoretical streams at the same time. Thus, they can move away from a narrower, accomplishment-based perspective, and help to deeply understand what happens when territories, more-than-human relations and co-learning practices interact in historic environments, landscapes and ecologies.

The need to combine the different levels of analysis by working on the macro-micro link seems evident.

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