Envisioning nature positive futures for Europe: Inspiring transformative change at the biodiversity nexus

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Abstract: Transformative change is required to secure a liveable future for people and nature. The Nature Futures Framework (NFF) is a heuristic tool to facilitate the creation of plural visions of nature positive futures that help build shared motivation for transformative change. Integrating nexus approaches with the NFF leverages the foundational role of biodiversity in supporting desirable outcomes across sectors and scales (i.e., the biodiversity nexus). In this paper, we bring these areas of biodiversity research together by co-creating plural visions of nature futures for Europe that make positive synergies within the biodiversity nexus explicit and consider transformative changes to the state of indirect drivers that enable them. In doing so, we aim to reflect upon methodological insights for future applications of the NFF. Nature futures for Europe were co-created with 26 participants representing diverse sectors and regions in Europe, resulting in three visions underpinned by different value perspectives: Dòigh Nàdair: The way of nature (Nature as Culture), NaturAll (Nature for Nature), and Return to Nature (Nature for Society). Subsequent analyses and a webinar enriched the narratives with possibilities for more synergistic nexus interactions. The findings highlight how plural visioning processes can generate distinct visions with positive nexus synergies enabled by unique indirect drivers. Yet, the resulting visions also share common features with overlapping value perspectives that evolve through the process. The methodological advances reveal how explicit consideration of the biodiversity nexus can mitigate unintended trade-offs between diverse values of biodiversity and increase the overall ambition of biodiversity outcomes.

Keywords: transformative change, Nature Futures Framework, biodiversity nexus; IPBES; plurality, nature values, visions

This manuscript is a non-peer reviewed preprint submitted to Ecosystems and People.

1 Introduction

Biodiversity plays a crucial role in sustaining life on Earth. However, anthropogenic influences on the environment are degrading ecosystems, resulting in a loss of biodiversity and nature's contributions to people, and in some instances species extinctions (Jaureguiberry et al., 2023; McCallum, 2015). Biodiversity loss has significant impacts, including disrupting regulatory ecosystem processes and threatening nature's direct contributions to human wellbeing (Cardinale et al., 2012; Díaz et al., 2018). The potential crossing of biodiversity tipping points further increases the risk of nonlinear and systemic impacts on the functioning of the Earth system (Lenton et al., 2023). Despite widespread recognition of the urgency of the biodiversity crisis, biodiversity loss continues to accelerate, motivating growing calls for 'transformative change' (IPBES, 2021). This drive toward transformative change, i.e., fundamental, systemic shifts away from the existing systems (Chapin III et al., 2010; Moore et al., 2014), is supported by increasing global ambitions for biodiversity conservation under the Kunming-Montreal Global Biodiversity Framework, along with national and sub-national targets and commitments. Additionally, bottom-up actions aim to steward systemic change that improves human-nature relationships (Bennett et al., 2016).

Calls for transformative change bring to light important questions about the scope, scale and speed of change required to halt and reverse biodiversity loss. The failure to facilitate transformative change to date has been at least partially attributed to the lack of policies and practices that are systemic enough to mainstream biodiversity (Rounsevell et al., 2020). In response, scientists are advocating for more holistic policies and governance systems, which aim to situate biodiversity within a range of interconnected issues and sectors. These approaches fall under the concept of the 'biodiversity nexus' or a 'nexus approach', wherein biodiversity loss is addressed in an integrated and systemic way to identify synergistic actions that improve biodiversity alongside other sectors including water, energy, food, transport, and health (IPBES, 2019; Pascual et al., 2022, Kim et al., 2024). If taken seriously, the biodiversity nexus points to the need for change that not only directly addresses biodiversity conservation (e.g., establishment of protected areas), but for extensive, systemic changes across domains and scales of linked human and natural systems. Such transformative change refers to changes in the underlying causes of biodiversity loss, including indirect drivers of socio-cultural, institutional, economic, demographic and technological change.

Envisioning desirable futures plays an important role in motivating and building shared commitment for transformative change (Moore & Milkoreit, 2020). Dominant conceptualisations of transformative change characterize it as emerging when marginal 'seeds' or niche innovations effectively scale to higher-level systems, altering the identity and feedbacks of these systems in often irreversible ways (Bennett et al., 2016; Geels, 2002). In other words, transformative change simultaneously disrupts established structures and practices that perpetuate biodiversity loss across domains of the biodiversity nexus (e.g., 'predict-and-control' water management, or intensive agriculture) while also identifying, nurturing, and mainstreaming practices that hold promise for a more sustainable future (e.g., adaptive, nature-based water management, agrivoltaics or agroecological agricultural practices). Participatory, co-creation processes are increasingly being used to imagine visions of the desirable outcomes of these systemic changes, drawing from a range of creative and transdisciplinary methods to render the visions more imaginative and tangible (Hebinck et al., 2018; Pereira et al., 2018; Raudsepp-Hearne et al., 2020). These visions are used for a range of purposes, including to offer hopeful cultural narratives about possibilities for change and to inspire strategic action pathways to achieve them (Lazurko et al., 2023; McPhearson et al., 2016).

Importantly, transformative change is messier and more contested than this type of dominant conceptualisation might imply, as it also emerges from the diverse perspectives and value judgments of people with a stake in transformation (Leach et al., 2010; Stirling, 2014). Ignoring the plural and political dimensions of transformative change has myriad risks, including that actions taken in the name of transformation further justify business-as-usual thinking, do not reflect the diversity of needs and aspirations for change, or shift the burden of change to more vulnerable groups (Blythe et al., 2018). The Nature Futures Framework (NFF) helps to address these risks by offering a heuristic tool that aims to facilitate co-creation of plural, place-based visions of nature-positive futures drawing from diverse value perspectives (Kim et al., 2023; Pereira et al., 2020). The NFF was developed through the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) Task Force on Scenarios and Models through an iterative, co-creation approach, and aims to stimulate the development of nature futures that reflect a more inclusive and diverse scope of possibilities for change (see Section 2.1).

The NFF is now being used as a tool for structuring place-based visioning processes around the world. It has been applied at local and regional scales in Europe, including to evaluate the performance of nature recovery options across NFF value perspectives in an urban boundary landscape in England (Dunn-Capper et al., 2023), to develop desirable futures for a national park in the Netherlands using a combination of the NFF and futures methods (Kuiper et al., 2022), and to explore integrated scenarios for the functioning of ecological infrastructure in Switzerland (Mayer et al., 2023). Some studies are also applying the NFF at the European scale. For example, Quintero-Uribe et al. (2022b) use the NFF to evaluate the value perspectives reflected in pre-existing rewilding and nature's contributions to people participatory scenarios in Europe, Dou et al., (2023b) use the NFF to envision variations of spatial implementation of EU and global sustainability targets, and Fornarini et al., (2023) develop narratives of the future of nature protection in Europe across various themes such as protected areas, forestry, and freshwater ecosystems.

No visioning processes to date bring together the primary aim of the NFF – i.e., to develop plural visions that inspire transformative change for nature and people – with the systemic lens offered by the biodiversity nexus. Furthermore, IPBES's methodological guide calls for the need to experiment with and report on unique methodological approaches for operationalising the NFF. Here, we aim to address these gaps by 1) co-creating plural visions of nature futures for Europe with explicit consideration of the biodiversity nexus and 2) reflecting on our methodological approach for future applications of the NFF. Our approach aims to develop plural visions of desirable futures underpinned by different value perspectives of the NFF while making possibilities for synergistic action between biodiversity and other sectors explicit, including the indirect drivers of change that enable them. We do so through a participatory co-creation process with 26 participants as part of the Biodiversity Nexus: Transformative Change for Sustainability (BIONEXT) project.

2 Methods

2.1 The Nature Futures Framework

The NFF aims to guide the development of inclusive and transformative scenarios towards nature- and people-positive futures. It places human and nature relationships at the centre of the co-creation process by harvesting diverse participants' worldviews in developing new visions that can inspire transformative actions (IPBES, 2022a). The framework in Figure 1 presents three main value perspectives on nature that are widely understood in conservation research and practice (Pereira et al., 2020). The Nature for Nature perspective focuses on the intrinsic value of nature, as in sparing space for nature for it to thrive without human exploitation. The Nature for Society perspective

emphasizes instrumental values of nature as in diverse benefits people receive from nature. The Nature as Culture/One with Nature perspective presents relational and cultural values that show diversity and richness in how humans interact, co-create and co-exist with nature. These value perspectives are intricately intertwined with synergies and conflicts that are specific to the location and context. Nature futures scenario modelling aims to identify interventions that have multiple co-benefits and less trade-offs for nature and people (Kim et al., 2023). To ensure that these diverse worldviews and values of nature are considered in developing future visions, the NFF can be used as a heuristic for convening and opening dialogues with a broad range of societal actors in co-creating the futures we want to move towards (Durán et al., 2023).

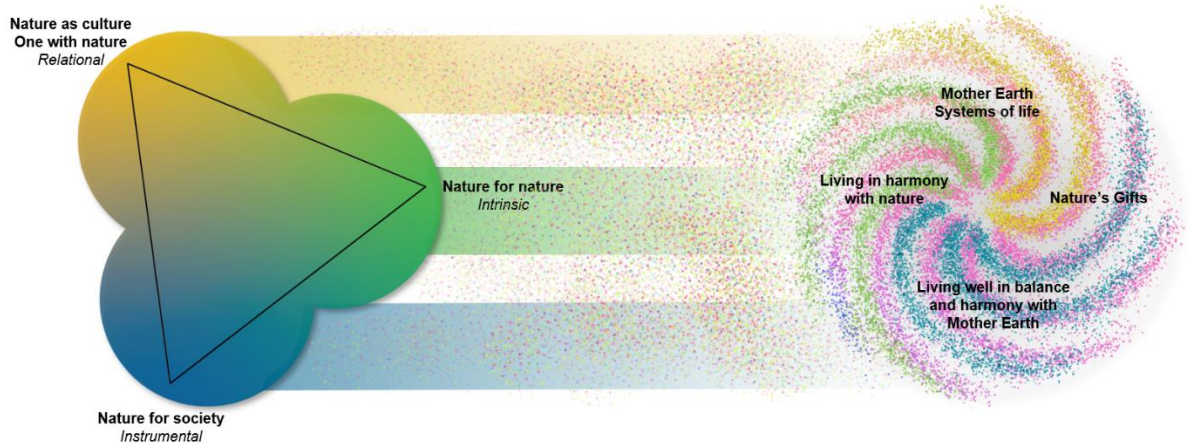

Figure 1: The Nature Futures Framework (IPBES, 2022a)

2.2 Vision co-creation, analysis, iteration and validation

The methodology for vision co-creation, analysis, iteration and validation is summarized in Figure 2. Key co-creation exercises that engaged researchers and participants are the vision co-creation workshop and vision iteration and validation webinar (yellow). Researchers synthesised and analysed the outputs of these activities to aid in iteration and validation (blue), and artists were engaged to help with communication and utilisation (green).

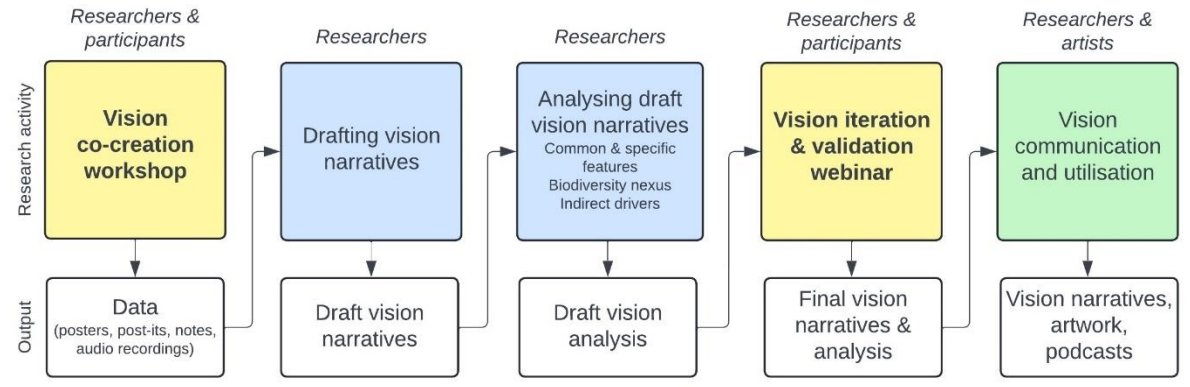

Figure 2: Summary of methodology for vision co-creation, analysis, iteration and validation

2.2.1 Vision co-creation workshop

The first co-creation workshop held on 4-5 May 2023 in Santorini, Greece, led participants through a structured process designed to co-create plural visions of nature positive futures for Europe. The 26 participants in the workshop represented all sectors considered in the BIONEXT project to constitute

the biodiversity nexus (i.e., biodiversity, water, food, health, energy and transport), organisational types (i.e., research organisation, government, civil society/non-governmental organisation, business and minority groups), and regions in Europe (i.e., western Europe, southern Europe, central/eastern Europe). Considerations were made for a balance of age, gender and other characteristics. Participants were selected through snowball sampling, starting from institutions and/or individuals known to the project team. The vision development activities are summarised in Table 1.

Table 1: Vision development activities during the vision co-creation workshop.

Session	Purpose	Activity
Day 1, Session 1	Familiarise participants with the three value perspectives on the NFF triangle	Facilitators presented the NFF and then participants were asked to think of an experience related to nature and to locate and discuss that experience by standing within an NFF triangle taped to the floor. This allowed participants to familiarise themselves with the NFF and position themselves relative to other value perspectives.
Day 1, Session 2	Brainstorm key elements of desirable nature futures for Europe	Participants were asked to brainstorm responses to the question: what themes are important to include in a desirable future for people and nature in 2050? A facilitator elicited and clustered key themes on a wall and worked with participants to give headings to each cluster.
Day 1, Session 3	Locate key themes from Session 2 on the NFF triangle to form three vision groups with three different value perspectives	Participants considered where each theme from Session 2 fit in relation to the three value perspectives on a large version of NFF triangle on the wall. Themes that were essential to all value perspectives or for which the underlying value perspective was uncertain were put on separate posters. Three final clusters determined the three value perspectives underlying three visioning groups.
Day 2, Session 4	Develop three narratives of desirable nature futures for Europe, underpinned by value perspectives from Session 3	Participants developed visions in pre-defined breakout groups with representation of the participant selection criteria. Participants were guided through a visioning meditation followed by collaborative completion of four posters designed to make the vision more detailed according to the following categories: core principles; environment and natural resources (including biodiversity nexus interactions); governance; economy, jobs and education; demographics, health and wellbeing; voice and equity.
Day 2, Session 6	Creatively present three narratives of desirable nature futures for Europe	Each group named their vision and prepared a presentation of their vision in the format of a ‘news story’.

2.2.2 Drafting vision narratives

Following the workshop, the data in the form of posters, post-its, notetaker notes and audio recordings were collated for each vision. Three researchers analysed the data for one of the three visions in parallel and inputted participant contributions relevant to the different themes on the posters used in Day 2 into a standard template. The contributions were summarised as descriptive bullet points and disagreements and contradictions between vision elements in the same vision were highlighted. Following this, a brief analysis of similarities and differences across the visions was conducted by a researcher who was not included in the initial analysis. The results of the analysis of similarities and differences were discussed, including resolving disagreements and contradictions, before the three researchers proceeded with drafting vision narratives (i.e., descriptive paragraphs

elaborating the vision of a desirable future) with narrative sub-sections according to the categories used to develop the narratives in Session 5 of the workshop (i.e., core principles; environment and natural resources - including biodiversity nexus interactions; governance; economy, jobs and education; demographics, health and wellbeing; voice and equity).

The vision narratives were subject to two levels of quality review. First, the three researchers who drafted the narratives evaluated the consistency of the analytical approach, level of detail and language across the two other visions. Second, another researcher independent of the initial analysis reviewed the narratives. The narratives were then refined based on feedback.

2.2.3 Analysing draft vision narratives

The three draft vision narratives were analysed to better understand common and specific features across the three visions, interlinkages of the biodiversity nexus and indirect drivers.

Common and specific features

An analysis of common and specific features helps elaborate the shared goals that frame what is inside the NFF triangle and the unique features that make the visions distinct (IPBES, 2023). The analysis started by comparing the state of five elements of the biodiversity nexus (i.e., biodiversity, water, energy, food, transport, and health) and the five generic domains of indirect drivers (demographic, economic, politics and institutions, socio-cultural, technological) across the three visions. This initial analysis then informed a summary of common and specific features according to the categories used to develop the vision narratives (i.e., core principles, environment and natural resources, governance, etc.). This analysis helped to further detail the specific features.

Biodiversity nexus

The three vision narratives were analysed for interlinkages of the biodiversity nexus. Sentences in the narratives that describe the state of the elements of the biodiversity nexus were highlighted and summarised in bullet points. The element of climate change was not included explicitly as it served as a broader driver rather than a vision element, though participants recognised that climate change adaptation and mitigation priorities would differ across the visions. The narratives were then analysed again to highlight statements that explicitly or implicitly link biodiversity to the other nexus elements (i.e., interlinkages both from and to biodiversity). These interlinkages were then contrasted to the current state by summarising the findings of the recent review of the current understanding of the biodiversity nexus in Europe (Kim et al., 2024).

Indirect drivers

The vision narratives were analysed to show how they addressed the indirect drivers of biodiversity loss as a signifier for transformative change – as transformative change requires fundamental change in these indirect drivers (Visseren-Hamakers et al., 2021). Comparing the visions to the current state in terms of demographic, economic, politics and institutions, socio-cultural and technological drivers showed which indirect drivers were more explicitly foregrounded in the visions. These indirect drivers were then analysed further to elaborate their role in enabling the fundamental changes required to achieve positive synergies in the biodiversity nexus. The categories of indirect drivers are based on the drivers of biodiversity loss and drivers of change included in the 2019 IPBES global assessment (IPBES, 2019a).

2.2.4 Vision iteration and validation webinar

A visioning webinar was held in February 2024 to validate and further elaborate the visions developed during the co-creation workshop. All participants who attended the vision co-creation

workshop were invited with 11 of the 26 original participants attending. Participants were sent the draft vision narratives beforehand. The activities of the webinar are summarised in Table 2.

Table 2: Visioning webinar activities.

Session	*Purpose*	*Activity*
1	Share the vision analysis from Workshop 1 and validate aspects of the visions that were identified as problematic or unclear	Plenary presentation of the three vision narratives followed by Mentimeter question and answer (i.e., online poll) with targeted questions for each vision.
2	Discuss and elaborate the analysis of elements and interlinkages of the biodiversity nexus and compare to the current state	Breakout group discussion on sub-sections of the biodiversity nexus (i.e., biodiversity-energy-transport, biodiversity-water-food, biodiversity-health). Participants collaborated on a Mural board to consider how they could enrich the state of nexus elements or better highlight synergies between elements in each vision, and to validate the characterisation of the current state.
3	Highlight the distinct aspects of the three visions by asking questions that allow participants to relate visions to one another	Plenary format, with facilitators reading out a question from Mentimeter and providing context from the current state (if relevant) and background from each vision. Participants ranked visions relative to one another according to the questions.

2.2.5 Vision communication and utilisation

The three final vision narratives were translated into communication products and for future co-creative exercises in BIONEXT project. The artist Lina Kusaite attended the vision co-creation webinar and worked with researchers through a series of iterative meetings to develop art pieces that reflect participants' contributions and stimulate new ideas and interpretations. In addition, the vision narratives were summarized as podcasts. These outputs aimed to stimulate the co-creation of transformative pathways that show the actions and strategies in the different nexus elements and systems required to reach each of the visions.

2.3 Reflecting on final value perspectives

The visioning process aimed to produce visions underpinned by plural values, which was done by orienting the three visions within different locations on the NFF triangle (see Session 3 of vision co-creation workshop). A reflection exercise with researchers and participants at the end of the co-creation process considered how each of the three visions evolved toward a particular value orientation. Participants reflected on the three visions during the vision iteration and validation webinar, where participants were asked "*Where would you place [vision name] on the NFF?"* via Mentimeter. To respond, they rated the degree to which the vision reflected each of three value perspectives on the NFF (Nature as Culture, Nature for Society, Nature for Nature) on a scale from 1 to 5. Researchers reflected on the value orientation the three visions after the narratives were finalised by responding to the same questions in survey format. The findings were averaged across participant and researcher contributions.

3 Results

3.1 Three visions of nature positive futures for Europe

The three vision narratives that emerged from the vision co-creation process are summarised below and presented in full in Annex 1. The visions are underpinned by different values for nature within

the NFF triangle. While these locations started closer to the corners of the three value perspectives, they also include elements between value perspectives (Figure 7).

Vision 1: Dòigh Nàdair: The way of nature (*nature as culture value perspective)*

In 2050, European society has a more pluralistic, balanced and reciprocal relationship with nature. People are guided by core principles of care and contemplation, and mainstream culture has a deeper spiritual and cultural connection with the natural world. Diverse and culturally embedded landscapes support flourishing ecosystems across Europe where human and natural processes are intertwined. Sustainable, regenerative and circular natural resource management nurtures a balanced relationship with the environment. Agricultural systems are community-based and rooted in agroecological and organic principles, and diets are local and seasonal with the little animal protein that is consumed supplied by pastoralists and small-scale fishers. Energy systems are renewable and configured to local needs and resources. Water is recognised as a commons and a human right, balanced with legal rights for water bodies. Governance systems are simple and localised, with strong connections to local landscapes and ecosystems. At higher levels, climate change and biodiversity considerations are mainstreamed within environmental, social and economic policies. The European Union embraces diverse worldviews and reorients toward being a good listener on the global stage, adopting an open borders policy. The economy in Europe is based on a degrowth and sharing model, rooted in stewardship and care. There is high equality of professions with universal basic income and more time for nature and community stewardship. Education systems are collaborative and embrace diverse forms of knowledge, preparing people for active citizenship. The population is stable but older and more diverse, with more people living in rural areas than is currently the case. Europeans have robust rights to healthcare including mental health, and have rediscovered the roots of natural and ancestral healing traditions to complement western scientific medicine. In 2050, Europe has achieved a more just and democratic society that prioritises active citizenship, stewardship and human rights. An artist interpretation of this vision is found in Figure 3.

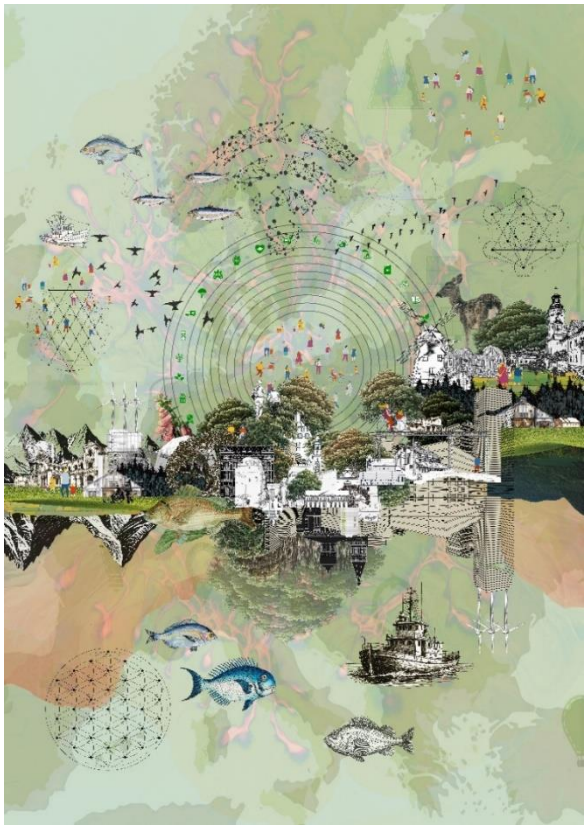

Figure 3: Artist interpretation of Vision 1 (Lina Kusaite)

Vision 2: NaturAll (*nature for nature value perspective)*

The importance of respecting nature for itself and giving space to natural ecological processes is highly valued among European society in 2050. Society is ecologically literate and adapts its activities to the dynamics of nature. Most people live in compact, self-sufficient cities and have lifestyles with low environmental impact. This is enabled by a sufficiency approach to energy demand, an energy system that is renewable and an active and or electrified mobility system. A preventative health approach improves lifestyles and wellbeing, reducing pressure on the environment of medical care. Water management adapts to and builds upon natural processes, such as through the removal of

channels and dams to give space to nature. In agriculture, a high (genetic) diversity of native species is prioritised, and nutrient cycles are balanced through integrated livestock systems. Diets are predominantly plant-based, seasonal and local. The governance system in place is multi-level and decentralized with most legislative power with the European Union and regional communities. The regional communities collaborate on the basis of solidarity and are (financially) supported by the EU. Moreover, there is a global platform for dialogue and collaboration which helps the EU negotiate zero-conversion trade policies. Within the EU, nature has been granted rights, which are implemented through democratic representation and courts. This ensures the rights and responsibilities that humans and nature have towards each other. Through degrowth and equitable distribution, the economic system has stabilised and is more local. Key indicators for prosperity are the state of the environment and wellbeing. People work fewer hours and focus their work on community and nature. Education is also more focused on ecological literacy and practical skills and partially conducted in informal community settings and in nature. The size of the population has stabilised after regulating migration into Europe. An artist interpretation of this vision can be found in Figure 4.

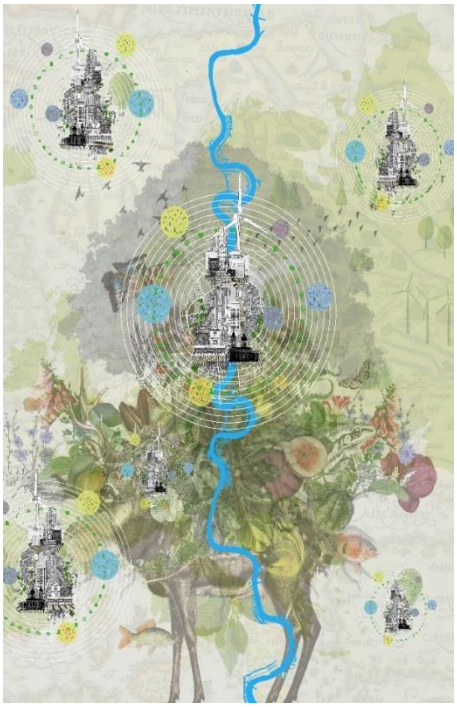

Figure 4: Artistic interpretation of Vision 2 (Lina Kusaite)

Vision 3: Return to nature (*nature for society value perspective)*

In 2050, European society has achieved a more balanced future for nature and people. Europe focuses on meeting the needs of nature and people with technological solutions, reduced consumption, and more highly valued biodiversity and water. Urban areas are community-based and transformed with nature-based solutions and green infrastructures. Biodiversity flourishes in rural areas with nature accessible where it exists. Rewilding takes place in forests, wetlands, mountains and rivers, which achieve good ecological status. There is an expansion of sustainable farming via circular economy, science and technology, and novel food sources to meet local and regional needs with reduced consumption. Water availability is improved with efficient storage, cities are greened with reused water resources, and coastal areas are protected by restored wetlands. EU policy and governance contributes to preventing wars, with extractive industries strictly regulated and higher independence from trade with mega countries. 60% of energy sources are renewable with improved technology, production and storage including smart grids in rural areas,

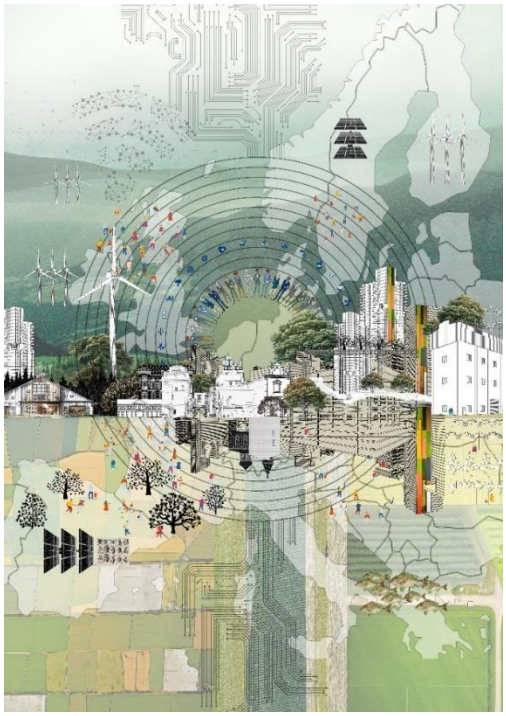

Figure 5: Artist interpretation of Vision 3 (Lina Kusaite)

biowaste and sewage contributing to energy production and nature conservation, and an overall reduction in energy use. More bikes are used than cars in cities. The EU manages pandemics better, with reduced disease risks, by securing space for nature and a decentralised health system reflecting diverse perspectives and practices. There are technology breakthroughs and skills development, and lifelong education adapts to the changing job landscape. The population has stabilised and equity has improved, with prosperous rural areas and spatial division between nature and human activities. An artist interpretation of this vision can be found in Figure 5.

3.2 Common and specific features in the three visions

Table 3 summarises the common and specific features across the three visions. This analysis reveals how the visions share common features that frame the outcomes of nature futures, such as reduced environmental impact, improved human wellbeing, and a transformed food system. By using the NFF, there are also distinct features reflecting different value perspectives, such as a greater focus on technological shifts in “Return to nature” versus socio-cultural shifts in “Dòigh Nàdair: The way of nature”.

Table 3: Summary of key elements of the three visions of nature futures for Europe

Key elements	**"Dòigh Nàdair: The way of nature"**	**NaturAll**	**Return to nature**
Primary value	Nature as Culture	Nature for Nature	Nature for Society
Core principles & values	Common: balanced relationship with nature and reduced environmental impact; biodiversity valued more and human wellbeing improved		
	• Pluralistic, balanced, and reciprocal relationship with nature • Care, contemplation, connection and respect • Deep spiritual and cultural connection to the natural world	• Value and recognise natural processes • Human activity adapts to natural processes • Ecological literacy and respect for nature • Solidarity between communities	• More balanced, practical, autonomous and local • Sparing space for, and restoring, nature • Meeting human needs while adapting to nature • Minimising ecological impact of Europe
State of biodiversity	Common: restoring ecosystems and conserving biodiversity via diverse landscapes and/or improved ecological connectivity		
	• Thriving, diverse and culturally embedded landscapes • Nature reserves actively managed with community ownership and equal access	• Highly diverse and well-connected landscapes • Majority of land allocated for nature exclusively • In those areas: stable population of keystone species and very high biodiversity intactness	• Biodiversity flourishing in rural areas • Nature-based solutions and green infrastructure in cities • Rewilding in forest, wetlands, mountains and rivers • Achieving good ecological status
State of environment and natural resources	Common: commitment to transforming the food system for sustainability with changes in farming, diet and reduced waste; enhanced water quality and management; transition to renewable and sustainable energy sources with minimized impact on nature and biodiversity		
	• Sustainable, regenerative and circular natural resource management • Community-based and agroecological agricultural practices • Local and seasonal diets with animal protein consumed less and supplied by pastoralists and small-scale fisheries	• Human activity builds on natural processes in agriculture (e.g., by prioritising native species) and protecting water and wetlands ecosystems • Minimised negative influence through energy sufficiency and renewable energy and reduction of chemical use and other pollution	• Sustainable farming via circular economy, science and technology, novel food sources to meet local and regional needs, and reduced consumption. • 60% renewables with improvements in technology, production and storage, e.g., smart grids for rural areas, biowaste and sewage contributing to energy production

	• Renewable and localised energy and transport systems configured to local needs and resources • Water recognised as a human right, balanced with legal rights for water bodies	• Transport is electrified and regulated through progressive pollution taxes • Natural processes facilitated by removal of dams and locks, and settlements relocated from flood plains	and nature conservation, and reduction in energy use • Improved water availability with efficient storage, greening the cities by reusing water, and protecting more coastal areas
Governance	Common: localised, participatory, inclusive and well-networked governance system; EU as a strong coordinator for solidarity and sustainability; governance and strategies mainstreamed to mitigate climate change		
	• Simple localised system, with strong networks connected to local landscape • Mainstreaming of climate and biodiversity across sectors and social policies at higher levels • EU embraces diverse values and worldviews, becomes a good listener with open borders	• Multilevel governance system mirroring natural processes • Most legislative power with the EU and with regional communities; solidarity between regions facilitated by EU • Rights for nature through representation and courts • Global platform for dialogue and collaboration	• Decentralised, polycentric, participatory and less technocratic • Legislative power in regional and national governance • EU plays a strong role in maintaining peace and reducing environmental impact • Reduced trade with major powers • Active integration of EU environmental policies
Economy, jobs, and education	Common: transition to more sustainable and community-oriented economies towards an equitable society; improved work-life balance as a result of a shift in the measure of success beyond economic growth; education for environmental, societal and technological challenges		
	• Economy rooted in stewardship and care, universal basic income within degrowth/sharing economy • High equality of professions, with more time for nature and community stewardship • Education prepares people for active citizenship and embraces diverse forms of knowledge	• Local and degrowth economy with equitable distribution of wealth. Prosperity indicated by wellbeing and environment • Fewer working hours, most jobs community and nature oriented • Education is more community-based and focuses on practical skills, ecological literacy and stewardship	• Decentralised and circular economy towards green and steady growth • Success measured on happiness and wellbeing • Reduced workdays with flexible job transition • Lifelong education, training skills development, harmonised minimum wage across Europe
	Common: stable European population; health is valued more with lifelong rights and access to healthcare; reconnecting with nature improves overall wellbeing		

Demographics, health, wellbeing	• Stable but older and more diverse population, with more people living in rural areas • Robust rights to healthcare; natural medicines and ancestral healing traditions complement western scientific medicine	• Stable population due to regulated migration • Majority lives in compact self-sufficient cities • Lifelong mental and physical health promoted through lifestyles and healthy food • Healthcare focuses on preventative approaches, and the natural rhythm of life is respected in older age	• Stable population with low birth rate, more people in cities, migration in Europe • Nature improves human wellbeing with reduced pandemic risks by securing space for nature • Pollution impact reduced on nature and people
Voice and equity	Common: more inclusive society with equity improved in wage, education and healthcare; shared concerns for social justice, equity and human rights		
	• A more just and democratic society with active citizenship, stewardship and human rights	• Communities have rights and responsibilities over nature and nature has rights and voice • Social justice agenda includes nature • Conservation through co-design with plural perspectives considered	• Citizens and countries with a stronger voice • Equity improved on wage, education and health

3.3 Transforming toward positive synergies in the biodiversity nexus

This section presents the analysis of the type of indirect drivers that enable the transformative changes required to achieve these positive synergies within the biodiversity nexus for each of the three visions. This is followed by a more granular analysis of pairwise positive synergies between biodiversity and other nexus elements (i.e., water, energy, food, transport and health), drawing from examples of which type of indirect drivers (i.e., socio-cultural, economic, political and institutional, demographic and technological) appear to most significantly facilitate the transformative change required to enable them.

Indirect drivers enabling positive synergies in the biodiversity nexus

The type of indirect drivers that appear more significant in enabling transformative change toward positive synergies in the biodiversity nexus are summarised in Table 4. All visions elaborate indirect drivers that signify a deviation from the current state, as defined by (Elbakidze et al., 2018; IPBES, 2018; Shaw et al., 2020; Stoddard et al., 2021), but each vision has a different rationale for which type of indirect drivers underpin transformation processes. In "Dòigh Nàdair: The way of nature", transformative change is driven by socio-cultural changes in people's connection to nature as well as a political change toward active citizenship. Alternatively, in "NaturAll" transformative change is driven by changing and institutionalising the inherent value of natural processes (e.g., legal protection of nature). Finally, in "Return to Nature", transformative change is driven by incentivising and regulating pollutive industries and by emerging technologies.

Table 4: Summary of current and future state of key indirect drivers enabling transformative change toward positive synergies in the biodiversity nexus per vision

Categories of indirect drivers	**Current state**	*Nature futures visions*		
		Dòigh Nàdair: The way of nature	**NaturAll**	**Return to Nature**
Socio-cultural	Materialistic norms, global trends, extractive approach to nature, perceived duality between nature and society	Building a more spiritual and reciprocal connection with nature	Adapting to natural ecological processes	Reconnecting with nature and reducing consumption
Economic	Global economies, decision-making focused on GDP growth, productivity and individual gain, linear resource economy	Prioritising degrowth and sharing/local economies, wellbeing	Prioritising degrowth and ecological wellbeing	Prioritising a circular resource and green/stable economy
Politics and institutions	Centralised power and governance structures, limited participation, minimal representation of nature, high levels of privatisation	Building active citizenship and stewardship	Granting legal protection of nature	Regulating environmental impact and reducing resource dependency
Demographics	75% of population live in urban and (sprawled) suburban areas	Re-ruralising society	Densifying to compact urban areas	Prosperous rural areas
Technological	Prioritisation of labour productivity and financial efficiency	Localising and motivating citizen involvement in infrastructure	Mainstreaming a sufficiency approach (i.e., reducing demand)	Prioritising sustainability and research/innovation in energy, food and water systems

Pairwise synergies in the biodiversity nexus, as enabled by indirect drivers

The explicit pairwise synergies between biodiversity and other nexus elements in each vision are visualised for the Food-Biodiversity interlinkage, summarised for other synergies, and described in full in Annex 2. These descriptions include both 1) the nature of the positive synergies in each vision and 2) examples of the specific indirect drivers facilitating transformative change to enable each pairwise synergy. The findings show how most interlinkages from other nexus elements to biodiversity in the current state are negative, reflecting how persistent unsustainability in other sectors drives biodiversity loss, as defined by a recent review of the current state of the biodiversity nexus in Europe by Kim et al. (2024). However, even in the current state interlinkages from biodiversity to other nexus elements are mostly positive, reinforcing the foundational role of biodiversity in many aspects of human life. In contrast, the three visions include more synergistic interactions from and to biodiversity. Positive synergies from other nexus elements to biodiversity highlight how more nature-friendly action generates a reciprocal relationship to biodiversity, facilitating a more balanced relationship between humans and nature across all three visions.

Food and biodiversity

The state of the interlinkage between biodiversity and food in the current state and the three visions is depicted in Figure . In the current state, expansion of agricultural land, agricultural intensification, monocropping, erosion of genetic diversity, rise of invasive species, and influx of nutrient and chemical inputs drive biodiversity loss and limit space for nature (Kim et al., 2024). Conversely, biodiversity underpins ecosystem processes that support food production. In “Dòigh Nàdair: The way of nature”, a more spiritual and reciprocal connection to nature and demographic re-ruralisation enables a food system that embraces local and seasonal diets and adopts agroecological, organic and community-based agricultural practices that enhance biodiversity. In “NaturAll”, more compact cities and agricultural land areas free up land for nature, and a society that values natural ecological processes enable the food system to value genetic diversity and use of native plants. In “Return to Nature”, scientific and technological advancements and financial incentives enable sustainable and diversified production of novel protein sources that free up land for nature and improve biodiversity.

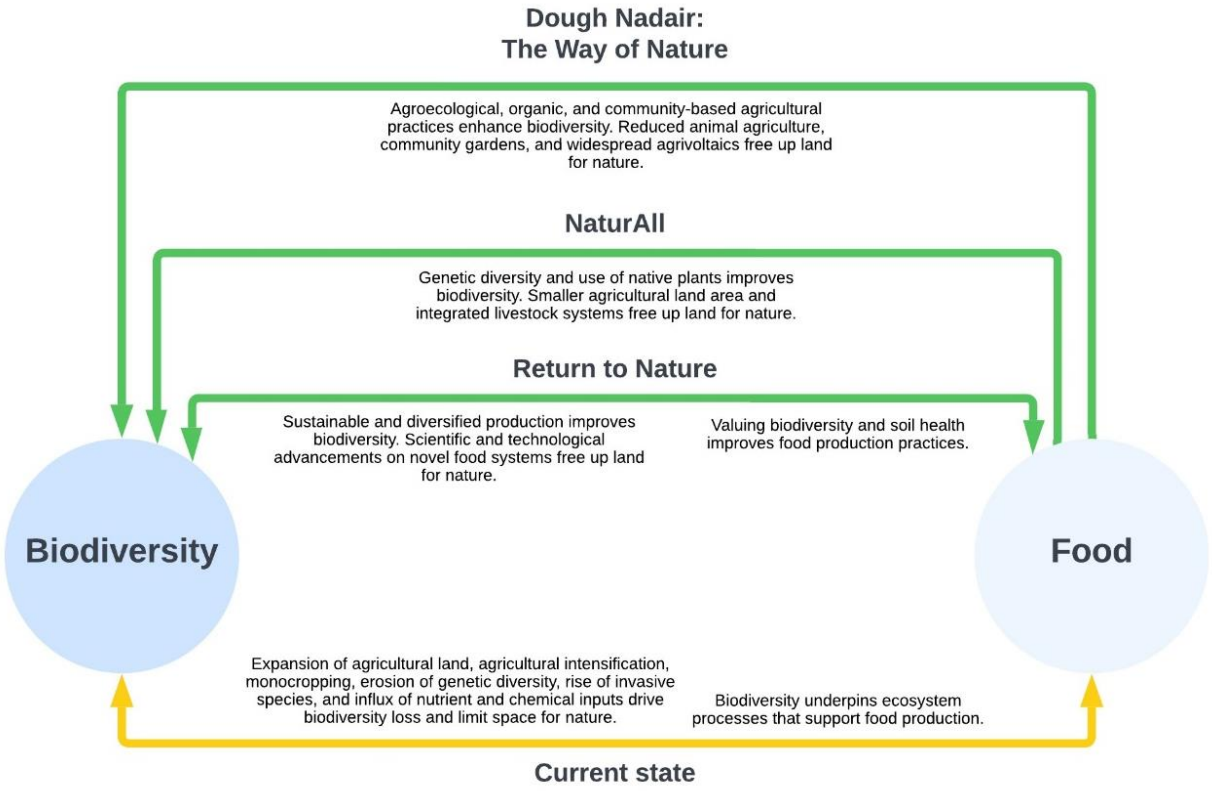

Figure 6: Interlinkage between food and biodiversity, including the current state and three future visions.

Health and biodiversity

The current state of the interlinkage between health and biodiversity is mixed. On one hand, pharmaceuticals and high energy use in the health sector impact the environment and ecosystem function in ways that can negatively impact biodiversity. Yet, biodiversity underlies many ecosystem services that are crucial for human health. In "Dòigh Nàdair: The way of nature", changes in socio-cultural norms enable a shift toward the use of natural medicines and access to nature as a complement to western medicine, enhancing wellbeing and biodiversity. In "NaturAll", socio-cultural acceptance of natural processes leads to lower chemical medication use that reduces pressure on the environment. In "Return to Nature", the state of health improves through people's increased connection to nature and technological advancements in the pharmaceutical industry reducing pollution impact on nature.

Energy and biodiversity

In the current state, energy infrastructure negatively impacts terrestrial and marine habitats and renewable energy production can increase competition for land. Furthermore, peat extraction for energy production, fossil fuel burning and fuelwood all reduce habitat quality. Yet, ecosystems can also provide a fuel source such as through sustainable harvesting of biomass. In "Dòigh Nàdair: The way of nature", changes in demographics, namely a re-ruralisation, and increased citizen involvement in infrastructure development enable widespread use of agrivoltaics (i.e., mixed solar-PV and agricultural production) that free up land for nature. In "NaturAll", the socio-cultural shift toward adapting to ecological processes leads to an energy sufficiency approach that reduces energy demand, thereby reducing the impacts of energy on biodiversity. In "Return to Nature", government regulations, reduced consumption and technological developments mitigate the impact of renewable energy on nature.

Water and biodiversity

In the current state, water infrastructure causes ecological fragmentation and alters flows in ways that contribute to biodiversity loss, yet biodiversity underpins ecosystem processes that support the water cycle. In “Dòigh Nàdair: The way of nature”, a rights-based perspective balances the rights of water bodies with the human right to water to enable an integrated water management approach as a commons that reduces pressure on biodiversity. In “NaturAll”, societal adaptation to natural processes improves that state of aquatic ecosystems and wetlands (e.g., by controlled withdrawal from floodplains and removing dams to give space to nature), which in turn improves biodiversity. In “Return to Nature”, expanded protection of coastal areas, technological innovations on storage and reuse, pollution control, and nature-based solutions improve water quality and availability which improves biodiversity.

Transport and biodiversity

In the current state, transport infrastructure harms nature as it causes species mortality, restricts species movement and reduces genetic diversity. Furthermore, marine and terrestrial transport systems spread invasive species, pathogens and disease vectors. In “Dòigh Nàdair: The way of nature”, demographic changes lead to more local production and consumption and therefore an overall reduction of transport and mobility that reduces pressure on the environment. In “NaturAll”, a different demographic shift (e.g., more compact cities) allows for more collective and active travel modes that have reduced environmental impact. In “Return to Nature”, there are limitations on private cars with increased use of active transport (e.g., bikes) in cities and more hydrogen and electricity-based transportation that improves biodiversity.

3.4 Reflection on value perspectives on the Nature Futures Framework

The starting positions of the visions on the NFF (cloud icons) and approximate end positions of the visions on the NFF (centroids of triangles) are depicted in Figure, based on evaluations from participants and researchers. The locations of the centroids relative to the starting positions show how the perceived value perspective migrated closer to the centre of the triangle than their original positions and how each vision was perceived to include significant elements of the different value perspectives. Importantly, these locations are approximate and based on the perceptions of researchers and workshop participants.

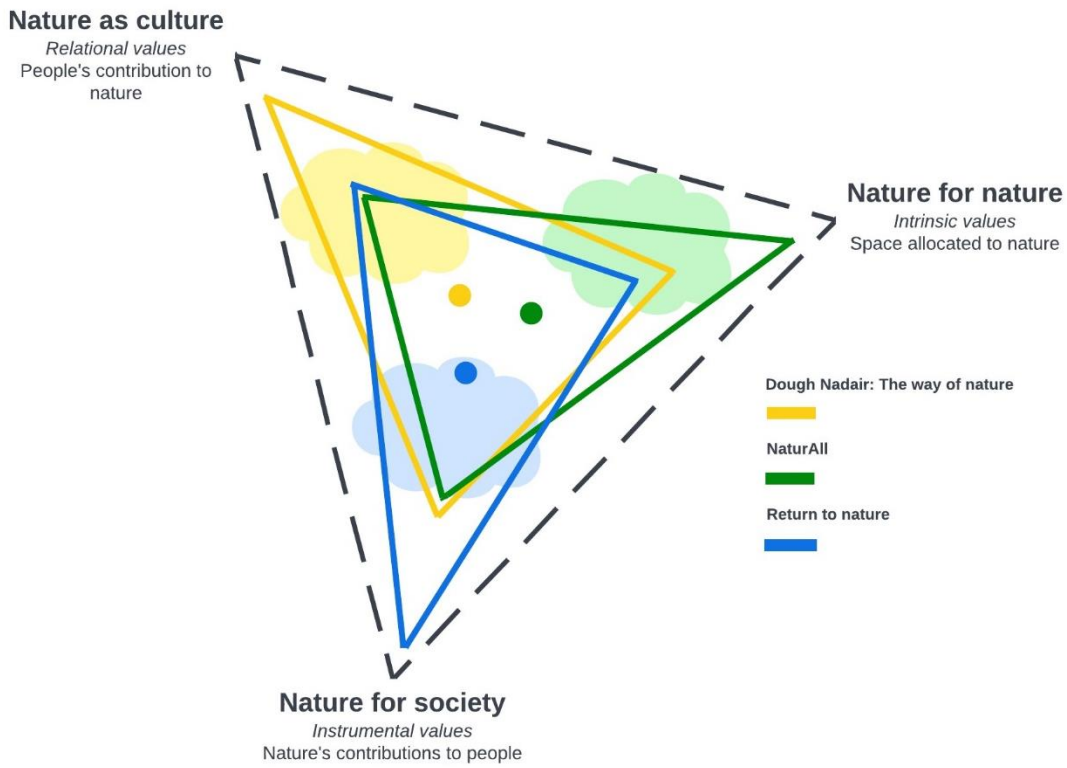

Figure 7: Starting and endpoint locations of visions on the NFF. The cloud icons correspond to the original starting points for vision development determined during the co-creation workshop. The points of the triangles are the mean of researcher and participant perceptions of the endpoint locations across researchers and participants for each vision. The circles are the centroid of the triangles.

4 Discussion

This paper presents a co-creative visioning process to develop plural nature futures for Europe with explicit consideration of the biodiversity nexus. The process developed three visions: "Dòigh Nàdair: The way of nature", "NaturAll", and "Return to Nature", each starting from three distinct value perspectives on the NFF. The common features across the visions reflect broad ambitions about which there was consensus among participants (e.g., to achieve a balanced relationship with nature), while the unique features often relate to the structures and processes of a landscape and society that enable them. For example, in "NaturAll", a balanced relationship is enabled by a society that mimics natural ecological processes, while in "Dòigh Nàdair: The way of nature", this balance is enabled by a spiritual connection with nature and in "Return to Nature", it is met through government regulations and technological solutions. This entanglement of shared versus unique features is reflected in the perceived location of the visions on the NFF, where the visions started toward the corners of the triangle but migrated toward the centre, potentially signifying more overlap across value perspectives. These findings offer important insights for the future of nature and people in Europe, where the heterogeneity of landscape and culture may call for a heterogeneity of visions and pathways to achieve them.

4.1 Contribution to nature futures visioning in Europe

This contribution in generating plural nature futures for Europe with explicit consideration of the biodiversity nexus is situated amid a range of studies applying the NFF to generate narratives of positive futures for nature and people. The visions developed here complement the illustrative global narratives used to demonstrate the value of the NFF (Durán et al., 2023). For example,

"NaturAll" closely reflects the "Arcology" illustrative narrative focused on Nature for Nature, reflected in their shared focus on compact cities and pristine nature areas, though "Arcology" is more technology driven. At the European scale, other visions for nature futures have been produced using different methodologies (e.g., Dou et al., 2023; Quintero-Uribe et al., 2022), with the most similar approach from the NaturaConnect project (Fornarini et al., 2023). The visions produced in the NaturaConnect project are organised according to the NFF and produced complementary visions to those presented in this paper. Yet, they were developed with a different focus (i.e., to develop narratives on future nature protection) according to different themes (i.e., protected areas, forestry, and freshwater ecosystems, etc) and assume a common baseline for indirect drivers (e.g., economy, governance, culture, etc.) instead of allowing their state to emerge from the visioning process. Such similarities and differences across narratives reflect the range of framings, contexts, and methodologies used to operationalize the NFF and enrich the imagined future state of Europe.

4.2 Methodological advances for applications of the Nature Futures Framework

This paper offers three important methodological advances for applications of the NFF. First, this paper used a structured approach to bring explicit consideration of the biodiversity nexus into a positive visioning process. The visions were first developed according to unique value perspectives during the workshop, resulting in draft vision narratives that in some cases were missing explicit consideration of nexus interactions or had hidden trade-offs. During the webinar, these draft visions were elaborated with explicit consideration of the biodiversity nexus, resulting in visions that reflect a holistic and systemic consideration of nexus synergies, thus responding to calls for consideration of nexus interactions in mainstreaming biodiversity across policy sectors (Rounsevell et al., 2020). In doing so, this paper has demonstrated how applying a nexus perspective in co-creative visioning can help synthesise opportunities for synergistic nexus interactions documented in the literature (e.g., Baldwin-Cantello et al., 2023; Hanspach et al., 2017; Kim et al., 2024; Timko et al., 2018) into coherent storylines to guide policy action.

Second, this paper allowed the future state of indirect drivers to emerge through the vision co-creation process. Doing so explored opportunities to address the foundational role of changing values in addressing the biodiversity crisis (DePuy et al., 2021; Leventon et al., 2021; Raymond et al., 2023), including overcoming narrow values of nature in politics and the economy to incorporate a more expansive set of values in decision-making (IPBES, 2022b). Importantly, the analysis of indirect drivers revealed how the most influential indirect drivers enabling transformative change toward positive nexus synergies vary significantly across value perspectives. For example, in "Dòigh Nàdair: The way of nature" several indirect drivers including socio-cultural shifts to human-nature relations, a demographic re-ruralisation, and a shift toward local economies enables positive synergies between biodiversity and food, health, energy and transport. In "NaturAll", a demographic change toward more compact cities and socio-cultural shift toward adapting to natural ecological processes were the primary indirect drivers enabling synergies between food, transport, health, energy and water. In "Return to Nature" technological advancements and socio-cultural shifts toward reduced consumption enabled positive synergies between biodiversity and food, health, energy and water. These findings affirm that the diverse values for nature in the NFF may also influence values underpinning the state of many indirect drivers, including society's relationship to technology or the economy. They also underline the need for careful attention to the unique opportunities to support the conditions for change of diverse indirect drivers across the European landscape in driving policy action.

Third, this paper allowed the underpinning value perspective to evolve through a co-creative visioning process. Tracing the perceived location on the NFF through the visioning process suggests

how visions may migrate from distinct toward a more overlapping and entangled mix of value perspectives. The exercise to make the visions more distinct during the webinar helped avoid unnecessary merging of the visions. In doing so, the process encouraged participants to consider how European contexts can achieve similar quantitative metrics (e.g., improved biodiversity or uptake of renewable energy) while looking significantly different on the landscape due to different underpinning value perspectives (e.g., proportion of land allocated for nature or percentage of people living in urban areas). Allowing for a flexible process in which value perspectives could evolve may have contributed to an enriched understanding that generated visions reflecting the diverse values of the participants.

4.3 Study reflection and limitations

This study has several limitations. While efforts were made to ensure diverse representations of regions, organisational types and sectoral expertise, the 26 participants in the study did not include all the perspectives across Europe, particularly as most participants were highly educated with above-average knowledge about the issues under discussion and excluded others including Indigenous Peoples, diverse socio-economic backgrounds, refugees, and people without professional expertise. Furthermore, researchers and participants observed that the outcome of co-creation processes may be influenced by the social dynamics within the visioning group. For example, participants in the "Return to Nature" group tended to evaluate the vision contributions based on the current reality, which in some cases resulted in vision elements that were undesirable to other group members, such as persistent gender inequality despite efforts to close the gap. Researchers reflected on a persistent challenge in which participants found it difficult to uproot from the limits of 'now' and envision a desirable future (Bendor, 2018; Pereira et al., 2019).

The choice to split participants into diverse groups while allowing for flexibility meant that participants did not fully align with the value perspective of their group, potentially contributing to inconsistencies in the visions. However, participants appeared to benefit from stretching their own values and perspective. Thus, the choice of how to split participants into visioning groups should be aligned with the explicit goal of the exercise – i.e., groups with aligned value perspectives can allow for consensus and more divergent vision narratives, whereas groups with more diverse value perspectives can stimulate dialogue and produce visions that may reflect the aspirations of a wider swathe of society. Finally, factors such as the amount of time and energy offered by participants, who is in the room, which methods are used for facilitation, and the choices and interventions of facilitators may influence the outcomes and results in direct and indirect ways (Lazurko et al., 2023), pointing to the need for multiple concurrent processes that together generate enriched pictures of the future of nature and people in Europe and beyond.

4.4 Future research and application

The contribution of this paper has the potential to unfold several areas for future research and practice. More methodological experimentation is required to combine the plural values of the NFF with the systemic insights of a nexus approach. Further research is also required to understand the implications of plural visions that maintain an entangled mix of common and specific features and overlapping value perspectives. Is it possible for Europe to move toward all three visions at once, and which combination of futures are current policies and practices creating? In particular, targets under global frameworks like the Kunming-Montreal Global Biodiversity Framework, the EU's Biodiversity Strategy to 2030, and national and sub-national targets and commitments could benefit from the broader range of options facilitated by a deeper consideration of the diversity of visions and pathways to achieve them. Additionally, critiques of the NFF point to its focus on human-nature values, which doesn't explicitly include consideration of other indirect drivers. However, the

approach described here makes other indirect drivers such as socio-cultural, economic and technological change explicit as well, which were also distinct across value perspectives and had unique contributions to positive synergies in the biodiversity nexus. Further research is required to understand the role of indirect drivers in enabling positive synergies in the nexus, particularly when translated to pathways.

Visions alone only hold limited transformative potential. To produce more action-oriented knowledge and test the feasibility of the visions, they are being used as inputs into a future workplan in the coming years, including a second co-creation workshop where participants will co-develop transformative pathways to achieve the visions. The pathways will also be evaluated using a nexus modelling framework, in which action pathways are modelled using an agent-based model (CRAFTY-EU; Brown et al., 2019), an integrated assessment model (IAP2; Harrison et al., 2019), and a new system dynamics model (Juniper; Ioannou et al., 2024). After the transformative pathways are modelled, the outputs will be evaluated to see whether the pathways achieved the visions, stimulating a learning process for both modellers and workshop participants. This comparison will inform subsequent steps in iterating and 'upping the ambition' of the transformative pathways.

Acknowledgments: The author team would like to thank all participants who participated in the vision co-creation process, including Hans-Martin Füssel (European Environment Agency), Russell Galt (Earthwatch Europe), Leea Mihaila (Agency of Brasov for the Management of Energy and Environment), those listed as co-authors to this paper, and all other anonymous participants. Thank you to the members of the BIONEXT project team who assisted with facilitation and practical workshop organisation, including Elizabeth Díaz-General, Zuzana Harmáčková, Hans Keune, Leena Kopperoinen, Soile Kulmala, Chrysi Laspidou, Mark Rounsevell, and Simeon Vaňo. Thank you also to Amanda Krijgsman for her early contributions to the study and to Lina Kusaite for her artistic contribution.

Funding statement: This work is supported by the EU Horizon Europe BIONEXT project No. 101059662, which is co-funded by UK Research and Innovation (UKRI) under the UK government's Horizon Europe funding guarantee 10039588.

Disclosure statement: The authors report there are no competing interests to declare.

Data availability statement: N/A

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Annex 1 – Full narratives of three visions

BIONEXT Vision 1: Dòigh Nàdair: The way of nature

Core principles

In 2050, European society is more pluralistic and has a balanced and reciprocal relationship with nature. People are guided by core principles of care, contemplation, connection and respect for the environment and one another. The role of local and traditional knowledge and practical wisdom are valued across society and within decision-making, and mainstream culture has nurtured a deeper spiritual connection to the natural world. Together, these core principles underpin a degrowth and sharing economy governed by localized, decolonized and well-networked institutions. Education systems are place-based and flexible and contribute to nurturing a strong commitment to nature stewardship and a spirit of conviviality.

Environment and natural resources

The environment in Europe is flourishing due to a balanced relationship between people and nature that drives sustainable and regenerative natural resource management. While a proportion of land is

reserved for nature, most of Europe is covered by culturally embedded landscapes where human and natural processes are intertwined. Circular economy principles are evident in the management of all natural resources, resulting in the production of very little waste. The environmental impact of daily life is known and visible, so people are motivated to work with and give back to nature in ways that account for the whole.

The agricultural system is community-based and rooted in agroecological and organic principles. Food production is decentralised in both rural and urban areas, with plentiful community gardens where people spend time contributing to food production. Diets are predominantly local and seasonal, supplied by regional food that is easy to access and produced through agroecological and other sustainable practices. Animal protein is consumed less, and that which is consumed is no longer supplied by industrial livestock farming but rather by pastoralists and small-scale fisheries. Food waste is minimal.

Energy systems are renewable, localized and configured to the unique resources, such as solar, wind, or hydropower, of each place. People also use traditional biomass for heating. People are involved in both consumption and production of energy through energy exchange at a local level, allowing everyone to become both consumers and suppliers of energy. The transportation system has changed dramatically and reduced requirements for energy, as more localised societies require less long-haul travel and the consumption of local goods requires less freight and shipping. This new system was achieved through a just transition that involved an equitable redistribution of energy demand (i.e., targeting wealthy, higher-demand consumers) and greater use of recycled materials for energy and transport infrastructure. Land use for food and energy production is highly integrated, such as through widespread use of agrivoltaics, which also reduces evaporation from agricultural fields.

People and institutions recognize access to water as a human right, and balance this with the recognition of legal rights of water bodies like rivers and lakes. This rights-based perspective informs an enhanced and integrated water management approach that improves the state of water bodies, which in turn removes pressures on biodiversity.

As a result of this reciprocal relationship between people and nature, seascapes and landscapes are thriving with plenty of diverse flora and fauna. Nature reserves are managed, and community ownership of nature allows access to everyone. The European landscape is highly diverse across different regions, reflecting the local ecology and culture of each place.

Governance

In 2050, citizens feel strongly connected to governance through participation within a simple and localized bureaucratic system. Local governments are strong, networked and connected to the local landscape, enhancing city-scale initiatives like carbon neutral cities. At higher levels, the climate and biodiversity agendas are mainstreamed across sectors and within social policies, including into human rights and migration policies. European-level policy commitments related to biodiversity, agriculture, and environmental aspects of the economy are well-implemented and robust, though European level commitments are less influential than local leadership and initiatives.

The EU embraces diverse values and worldviews in a manner that recognizes its position in the world and addresses its colonial past and present. As a result, the EU is a good listener in global negotiations and learns from other countries and Indigenous communities. The EU has open borders and strong and transparent regulations on trade, ensuring that impacts in distant places do not contradict EU values. This includes the regulation of international corporations and raw material

extraction, which recognizes that Europe cannot simply regulate other people's lands but can and should regulate how the EU relates to them.

Economy, jobs, and education

The economy is rooted in stewardship and care for nature and people over profit. Land ownership is shared, and people experience the true environmental and social cost of their actions and adjust to minimize them. Everyone receives a universal basic income focused on equality. This all occurs within a degrowth and sharing economy focused on human wellbeing, enhancing nature and circularity. This economic model facilitates strong connections within localised communities.

There is high equality of access to professionals across Europe. People have a different mindset about income and which jobs are 'vital', prioritizing care workers, doctors, teachers, foresters, farmers and artists. In addition to their regular jobs, people allocate time in their day to activities that steward nature and community wellbeing. As a result, people value skills such as teaching, growing, construction and childcare. There is no wealth hoarding due to proper taxation and regulation.

In contrast to the more individualistic and competitive education system of the past, the education system in 2050 prepares people to be active citizens, collaborate with others, and contribute to community wellbeing. Educational buildings are embedded in nature, housing a curriculum that is values- and skills-based with a focus on environmental education and local knowledge. Students learn how to exercise creativity and imagination through teamwork, collaboration, debate and discussion. The curriculum adapts to different learning styles including neurodiversity and embraces the role of formal versus informal education. It also offers diverse teaching streams catered to different job types (e.g., farmers). Students are not evaluated with traditional assessment methods like exams but rather broader metrics of learning. Everyone has equal opportunities to learn via a 'knowledge commons', supported by a more open scientific community and appropriate technologies.

Demographics, health, wellbeing

The European population is relatively stable with lower birth rates but higher migration, with more people living in rural areas. However, the structure of the population has shifted dramatically, with a more diverse population (i.e., due to open borders) and many elderly people. In recognition of this shift, Europe has established intergenerational structures of care to replace old age homes.

Human wellbeing is nurtured through open borders, open hearts and open minds. People have robust rights to health care, including mental health. This includes reproductive rights and bodily autonomy, safe housing, access to green spaces, fewer working hours, and laws protecting human wellbeing including the right to leisure. Natural medicines and ancestral healing traditions are embraced, complementing western scientific medicine. Wellbeing is supported by community and social networks, strong labour rights, and ownership of the means of production. A major component of this wellbeing is facilitated through having more *time* available.

Voice and equity

European society prioritizes active citizenship and democracy, collective ownership, stewardship and human rights related to gender, race, sexuality, access to basic needs and a healthy environment. In 2050, Europe has achieved a more just and democratic society.

BIONEXT Vision 2: NaturAll

Core principles

In 2050, European society is more ecologically literate and respects nature for itself. The importance of natural processes is recognised and highly valued, forming the core principle underlying human-nature interactions. Human activities are adapted to the dynamics of natural systems and human pressures on the environment are reduced as much as possible. Governance is multi-level and decision-making is decentralized to connect with local ecosystems and cultures. Strong solidarity between communities ensures cooperation and decision-making that prioritises nature.

Environment and natural resources

Ecosystems and their natural processes have been largely restored to create highly diverse and well-connected landscapes across Europe. The boundaries between ecosystems are indistinct to avoid fragmentation and barriers to the movement of species. Negative influences from human activities on ecosystems are minimised. This ensures that human impacts on the environment are maintained well within planetary boundaries. This includes significant reduction of chemical, biological and other (e.g. solid waste) pollution leading to high water, air and soil quality. Human use of natural resources is determined by the natural value of each area. This results in the majority of land areas being left as pristine nature, i.e., allocated for nature exclusively. Biodiversity is thriving within these areas, which have stable populations of keystone species and a biodiversity intactness index of 80-90%. While in other areas agriculture or cities have been designed to co-exist with nature.

Rivers follow their natural courses and are no longer managed by dams and locks nor forced into artificial channels. Aquatic ecosystems and wetlands are protected which provides benefits for both the natural systems (e.g. through the restoration of shellfish banks) and availability of drinking water and agriculture. Settlements have been relocated from flood plains or made adaptable so that seas and rivers can naturally flood.

This adaptation to natural processes is also seen in food systems. Production systems build on ecological processes – rather than supressing them – and mimic nature, supported by high genetic diversity in crops that prioritize native plant species. Integrated livestock systems ensure resilience and a balanced nutrient cycle. Agricultural areas are compact with blurred boundaries between farmed and natural land connected by food forests and other edible landscapes.

Energy is fully renewable and to limit land and resource use the idea of energy sufficiency is adopted. Fossil fuels have been phased out and greenhouse gases emissions are net zero or net negative to minimise the negative impacts of climate change on nature and people. Energy efficient products and smart use of natural resources and materials ensure minimum environmental harm. The transport system also has a minimal negative impact through the adoption of predominantly electrified and collective (e.g. through electric trains) or active (e.g., cycling, walking) modes. Regulation ensures these negative environmental impacts remain minimal through a progressive tax.

Governance

Governance is multi-level representing the different scales of influence of natural processes and respecting the interconnectedness of different natural areas. The EU has a strong legislative power in issues that affect larger geographic scales. Yet, regional communities maintain a strong voice in decision-making, so the majority of governance operates at a scale that best represents local culture as well as local ecosystems. This also ensures that power is distributed within a decentralized governance system. There is a high level of solidarity and cooperation between regional communities.

On a global scale there is a strong global platform for dialogue and collaboration that has effectively addressed global environmental issues, including climate change and biodiversity loss. The European Union works in partnership with this global governance body to guarantee zero-conversion trade and protect vulnerable ecosystems outside its borders. This includes ensuring that imports and exports do not negatively impact nature outside of Europe. The EU makes resources available to regional communities to support these rights and to conserve and protect nature. Europe has embraced rights for nature and ecological systems. This is done through representation in democratic systems, constitutional legal protection and an international court overseeing natures rights.

Economy, jobs, and education

The state of the environment and wellbeing are recognised as key indicators for assessing prosperity. The socio-economic value of nature for providing clean water, nutritious food, mitigating climate change, and ensuring good physical and mental health is fully reflected in a transformed economic system. This results in economic degrowth and eventually stable local economies that define wealth in terms of wellbeing rather than money. In this economic system, individual wealth is considered to be less important than the equitable distribution of wealth. People work fewer hours and spend more time on other activities that are valued, such as time in nature. Jobs are generally community-based with a particular focus on outdoor and service-based jobs. The economy also invests in targeted technological innovations related to resource use efficiency, nature restoration and monitoring.

The education system promotes practical skills, ecological literacy and stewardship, with at least 20% of education taking place outside in natural areas. Improving ecological literacy goes beyond formal education with nature centres embedding informal education and lifelong learning within communities. Many opportunities exist for people to participate in conservation community-service through so-called ‘Nature Corps’ or citizen science activities for monitoring the health of biodiversity and nature.

Demographics, health, wellbeing

Health is approached in a preventative manner, with good health promoted throughout life and prenatally. Health promotion focuses on exposure to nature to improve mental and physical health, active lifestyles, and the provision of healthy food for everyone. This is embedded in active mobility systems, which involve daily activities in nature and with the community. In providing health care, the natural rhythm of life is respected, and heavy medication and care is no longer prioritised for sustaining life at all costs. As a result, the production of medicines has decreased, and chemically based medicines are less readily available. This results in less pressure on natural resources, less pollution from chemical production processes, and a shift in cultural norms and expectations around medical treatment.

Population growth has stabilised in Europe, partially due to regulations to lower influx of migration from outside of Europe. Lifestyles are sustainable and low consuming in terms of food, water and energy. Diets are largely plant-based, seasonal and local. People live both in cities and rural areas, but the majority of the population is located in compact and largely self-sufficient cities to make space for nature. Cities are green and connected with the landscapes surrounding them.

Voice and equity

Nature has a legal voice and rights that are respected by society. Communities provide universal and responsible access to high quality green space, while at the same time providing universal access for nature to human space. Social justice and equity are mainstreamed throughout governance and

society, with non-human entities included in the justice agenda. Nature conservation is co-designed within communities using socially inclusive processes that take account of different voices (youth, future generations, non-human) and different worldviews (scientific, spiritual). By upholding principles of co-design and voice and rights for non-humans the dominance of humans in nature is avoided.

BIONEXT Vision 3: Return to Nature

Core principles

In 2050, European society has achieved a more balanced future for nature and people in which human needs are met without comprising nature and natural processes. Europe has adopted practical approaches for improving education, training, wages and equity across societies, while sparing space for and restoring nature. This has improved the services people receive from nature which have been enhanced through locally driven practices and appropriate use of technology. Within Europe, more autonomy and power has been devolved to the member states, with the European Union acting as a coordinator of regional governance. Europe has also reduced its ecological impacts on the rest of the world.

Environment and natural resources

Food and energy production and consumption and water regulation and provision are managed to create synergistic outcomes for both human wellbeing and biodiversity conservation in both urban and rural areas. Cities are greener, with integrated green infrastructure, such as green rooftops and vertical gardens. Active transport (e.g. walking and cycling) is promoted, while the number of private cars is limited with mandatory zero emission goals in cities. Technological solutions focus on efficiency, electrification and synthetic fuels for both land and ocean transport systems. Cities have strong communities with local markets and community gardens. Nature-based solutions are an integral part of the urban system, particularly to increase resilience to climate events.

Nature is highly accessible to urban citizens, with cities surrounded by diverse landscapes and flourishing biodiversity. Rural areas are prosperous and self-sufficient in food and energy production. Land use in rural areas is shared with nature with some land dedicated to restoring nature. In these areas, rewilding takes place in forests, wetlands, mountains and rivers to achieve good ecological status. Hedges have also been restored across landscapes to help connect human-dominated, natural and wilderness areas. Managers of resources (e.g. agriculture, forestry, fishery) are more engaged in biodiversity protection.

The food system is underpinned by principles of sustainable and diversified production and healthy and reduced consumption that are delivered through technological innovation, circular economy approaches, and changed diets and lifestyles that reduce consumption and food waste. Sustainable farming in rural areas is supplemented by urban farming and novel sources of food (insects, lab meat, etc.) with commitment and financial incentives. In rural areas, farmers not only produce food but also oversee the management of the landscape, requiring new skills and incentives. Farmers understand the social and economic values of biodiversity and there is new norm of valuing healthy soil.

The value of water is recognised, with threats to water availability from droughts and floods and irrigation needs for agriculture countered using nature-based solutions, efficient storage systems and desalination technologies to improve water regulation and availability. Water use for cultural and health purposes is increased while reuse of water is promoted within the green cities. Water

quality is improved due to large reductions in pollution from microplastics and urbanization of the coastal areas with commitment and financial incentives. Coastal areas are protected and largely spared for nature with only a few areas remaining for human activities.

Energy is provided by over 60% renewables with a careful consideration of its impact on nature. Reduced energy consumption and the use of energy recovery technology contribute to lower energy needs. The energy system is decentralized with energy sources optimised depending on what is most appropriate for each region and using technology for its production, storage and distribution (e.g. smart grids). The impact of renewable energy on nature and biodiversity is minimized. More efficient processing of biowaste and sewage contributes to energy production and nature conservation.

Governance

The European Union is more decentralized and polycentric with more legislative power in the regional and national governance. Citizens have a strong voice in decision-making as governance is more participatory and less technocratic. The role of the EU focuses on strong regional coordination of green legislation that is integrative and inclusive. Member states have autonomy to implement actions in accordance with these legal frameworks.

The EU plays a strong role in maintaining peace in Europe and preventing major global conflict, which reduces environmental impacts worldwide. The environmental impacts of trade from countries outside Europe are minimized by reducing trade with mega-countries such as China and Russia.

Economy, jobs, and education

The economy becomes more socially responsible in production and development towards green and steady/stable growth. It becomes more decentralized and circular with technology breakthroughs, skills development, and socially and ecologically responsible practices by the private sector. Success is no longer measured in terms of GDP but in indicators related to happiness and other well-being measures.

A better balance is achieved between professional and personal life with retirement age increasing to 70 due to increased life expectancy. People work four days a week with the flexibility to retrain and transition between jobs and sectors. A wide range of job opportunities are available, including in industries related to the circular economy and in local farms where farmers manage the delivery of multiple ecosystem services at the landscape level. The extractive industry is regulated to protect the environment and ensure maintenance of ecosystem functions that are vital to human wellbeing. The gap between the rich and the poor is lower and further improvements are supported by training and the harmonization of minimum wages across Europe.

Formal and lifelong education occurs in all EU Member States, particularly focusing on the development of new hard and soft skills for new occupations and new technologies, such as Artificial Intelligence.

Demographics, health, wellbeing

The population in Europe is stable but with low birth rates due to changing family and social structure. More people live in the cities with citizens migrating across EU Member States due to extreme weather, social and technological changes. Some migration from outside the EU occurs, particularly to supplement skills where needed.

Reconnecting with nature becomes central to wellbeing, which reduces diseases such as cancer and allergies. Chemical pollution has reduced impact on nature and people given transformative change

in the medical system and pharmaceutical industry (e.g. biomimicry, ecologically friendly chemicals). The EU is equipped to manage pandemics better and there is a reduced risk of spread of viruses from animals as a result of securing space for nature globally. Centralising the health system is challenging in the EU given diverse perceptions on health, wellbeing and lifestyle, but there is equitable access to health services including medication and medical facilities.

Voice and equity

Citizens and countries have a stronger voice in the EU. There is an increased opportunity for continued education and improved equal access to health benefits. The minimum wage becomes more comparable across countries in Europe.

Annex 2: Interlinkages between biodiversity and other nexus elements in the current state and each of the three visions

Element	*Current system*	*Vision 1: Dòigh Nàdair: The way of nature*	*Vision 2: NaturAll*	*Vision 3: Return to Nature*
Food *influencing* ***Biodiversity***	- Expansion of agricultural land, agricultural intensification, monocropping, erosion of genetic diversity, rise of invasive species, and influx of nutrient and chemical inputs drive biodiversity loss and limit space for nature (Kim et al., 2024)	+ Agroecological, organic, and community-based agricultural practices enhance biodiversity + Reduced animal agriculture, community gardens, and widespread agrivoltaics free up land for nature	+ Genetic diversity and use of native plants improves biodiversity + Smaller agricultural area and integrated livestock systems free up land for nature	+ Sustainable and diversified production improves biodiversity + Declined population (and lower food demand), urban farming, and more circular, novel systems free up land for nature
Biodiversity *influencing* ***Food***	+ Biodiversity underpins ecosystem processes that support food production (Kim et al., 2024)	*Not explicit in vision narrative*	*Not explicit in vision narrative*	+ Valuing biodiversity changes food production practice
Health *influencing* ***Biodiversity***	- Pharmaceuticals and high energy use in the health sector impact the environment and ecosystem function in ways that can negatively impact biodiversity (Kim et al., 2024; Sumpter et al., 2024)(Kim et al., 2024; Sumpter et al., 2024)	*Not explicit in vision narrative*	+ Lower chemical medication use reduces pressure on the environment (e.g., pollution)	+ Transformation of the pharmaceutical industry reduces chemical impact on nature
Biodiversity *influencing* ***Health***	+ Biodiversity underlies many ecosystem services that are crucial for human health, e.g., reduction of air pollution, source of nutrition and medicines (Kim et al., 2024)(Kim et al., 2024) + Access to nature improves human health, e.g., forest walks promoting cardiovascular relaxation (Kim et al., 2024)(Kim et al., 2024) + Transmission and burden of infectious diseases lower in animal species-rich, natural environments (Kim et al., 2024)(Kim et al., 2024)	+ Access to nature improves wellbeing + Natural medicines provide complement to western scientific medicine	+ Access to nature promoted as a way to improve mental and physical health	+ Reconnecting with nature improves health + Securing space for nature benefits human health with reduced risk from diseases
Energy *influencing* ***Biodiversity***	- Infrastructure such as offshore wind turbines and hydropower dams negatively impact terrestrial and aquatic/marine habitats and species (Kim et al., 2024)(Kim et al., 2024)	+ Widespread use of agrivoltaics frees up land for nature	+ Concept of energy sufficiency limits land area required for energy, freeing up land for nature	+ Impact of renewable energy on nature minimized

	- Peat extraction for energy production, fossil fuel burning, and fuelwood all reduce habitat quality (Kim et al., 2024)(Kim et al., 2024) - Renewable energy and bioenergy production can increase competition for land, contributes to intensification that puts pressure on ecosystems (Kim et al., 2024)(Kim et al., 2024)		+ Energy efficient products and smart use of resources minimises environmental harm	
Biodiversity *influencing* ***Energy***	+ Ecosystems can provide a fuel source, such as through sustainable harvesting of ground biomass (Kim et al., 2024)(Kim et al., 2024)	*Not explicit in vision narrative*	*Not explicit in vision narrative*	*Not explicit in vision narrative*
Water *influencing* ***Biodiversity***	- Water infrastructure (e.g., dams and reservoirs) cause fragmentation and alter flows, contributing to biodiversity loss (Kim et al., 2024)(Kim et al., 2024) - Poor water quality negatively influencing biodiversity; e.g., acidification leading to fish loss (Kim et al., 2024)(Kim et al., 2024)	+ Integrated water management approach reduces pressure on biodiversity	*Not explicit in vision narrative*	+ Use of nature-based solutions for water management can improve biodiversity
Biodiversity *influencing* ***Water***	+ Biodiversity underpins ecosystem processes that support the water cycle, and high water quality enables ecosystem function (Kim et al., 2024)(Kim et al., 2024)	*Not explicit in vision narrative*	+ Aquatic ecosystems and wetlands improve availability of drinking water	+ Green cities facilitate improved water management
Transport *influencing* ***Biodiversity***	• Transport infrastructure causes species mortality, restricts movement, reduces genetic diversity, and contributes to biodiversity loss (Kim et al., 2024)(Kim et al., 2024) • Marine and terrestrial transport systems spread of invasive species, pathogens, and disease vectors (Kim et al., 2024)(Kim et al., 2024) • Production of electric vehicles can negatively impact biodiversity through resource use (Kim et al., 2024)(Kim et al., 2024) Production of renewable energy for transport (e.g., biofuels) can impact biodiversity (Kim et al., 2024)(Kim et al., 2024)	+ Reduced transportation requirements (e.g., due to localised communities and supply chains) reduces pressure on land and environmental pollution	+ Minimal negative environmental impact from electrified public and active modes of transit	*Not explicit in vision narrative*

Biodiversity *influencing* ***Transport***	*N/A*	*Not explicit in vision narrative*	*Not explicit in vision narrative*	*Not explicit in vision narrative*