interNationaL2120

Moving from nature based solutions scenarios in the Netherlands to international and LMIC contexts

Authors: Thomas Tichar and Thirze Hermans

Summary

In 2019 and 2023 Wageningen University & Research published future scenario reports, the first on how the Netherlands could look like from a nature-based solutions perspective, the second at the scale of Europe. In this study the two 2120 scenario reports are taken as a starting point for whether and how their approach and results can add value to nature positive futures work more broadly, and for LMIC country contexts. The introduction provides more background on the 2120 reports and the motivation and key questions for this study. Following this the framing NL2120 and EU2120 in the Nature Futures Framework section introduces the NFF, a broadly used heuristic tool developed by IPBES for guiding the design of nature positive futures. It is used as reference to determine whether and how the 2120 exercise and results could be applied in other contexts around the world. Then the historical drivers and future trends goes into more detail on broad-based drivers and trends for global warming (using CO_2 as a proxy) and loss of biodiversity (looking respectively at genetic, species and ecosystem diversity), how they differ in richer and poorer parts of the world, and given this what some potential future trends are. Towards governing nature positive futures in different contexts then gives a brief overview of what existing nature-based activities and scenario exercises are already taking place in different parts of the world, including in LMICs, and how the 2120 approach could support these. The challenge of just transitions – balancing nature and human needs – suggests improved governance is needed. The conclusions and recommendations reflect on key points and propose next steps.

Key messages

1 The 2120 approach applied to the Netherlands and Europe as an integrated mapping tool can be applied in low and middle income countries (LMICs) provided its methodology is further developed to more explicitly take into account 'just transitions', e.g. mapping pathways that ensure those impacted the most by the transition towards nature positive futures also benefit from this in both the short, medium and long-term.

2 Integrating the 2120 approach and Nature Futures Framework is a good first step to more explicitly addressing both nature and socio-economic challenges. But neither consider the governance models required to manage these transitions. Tools to develop this must be included to convert the visioning and pathways exercises into more tangible steps to actual implementation.

3 Wealth and consumption, not population growth, are the key drivers of global warming and decline in biodiversity. Regional and global supply chains mean that disparate geographies become 'telecoupled' so that one country's carbon and biodiversity footprint extends far beyond its borders. In futures and scenario exercises these trends and drivers need to be explicitly taken into account.

4 Developing a 2120-NFF integrated and further developed methodology should be done through practical application in a LMIC country or region. Selecting where should be based on 1) demand by local, regional or national stakeholders, 2) stakeholder capacity to implement the results, and 3) build on existing nbs initiatives that are already being implemented.

5 Given the potential integration and further development of the two methods WUR is seeking opportunities to apply this where there is an interest to do so. For follow-up please contact the authors.

Introduction

A 2019 Wageningen University & Research (WUR) report, published a map (see 2120 maps on next page) of how the Netherlands could look and function one hundred years later in 2120 applying nature-based solutions (for definition, see box 1). It received a lot of positive response in the media, government and various other stakeholders, including mayors to farmer groups, showcasing a broad engagement. The emphasis of the report was an integrated soil-water system approach to simultaneously address multiple challenges, and which focused on "a map of what is possible, i.e. feasible and realistic when future choices on the use and layout of The Netherlands are based on understanding natural systems and processes" (Baptist *et al.*, 2019). The vision was emphatically designed not as a utopia, but nevertheless "giving priority to nature, a sustainable economy, quality of life and safety" (Baptist *et al.*, 2019) and used as its basis.

Since then a number of regional and municipal initiatives have begun to detail out what steps would need to be taken to work towards this kind of a future with nature based solutions at its core. For example, WUR provided recommendations to the town of Arnhem on how it could look applying the same integrated nature-based approach (*ARNHEM2120 - Durf vooruit te kijken*). This engagement also resulted in an investment of €110m into a NL2120 knowledge and innovation program for further research by the Dutch government in 2022. It also formed the inspiration for a European-scale vision 'Imagining a nature-based future for Europe in 2120' (Hattum *et al.*, 2023) (EU2120 for subsequent reference), published in 2023 and presented in Brussels during an annual lecture series to policy-makers and other stakeholders (see 2120 maps on next page).

Given this leap of scale from national to continental level, the question arises, how applicable and useful is this approach in other parts of the world? Or, put another way, what contribution can this approach make to the ongoing plethora of initiatives around the world that relate to both futures and scenario work for nature-positive natures, as well as current policy-making and on-the-ground work? And finally, to what degree does context matter for such a process? The Netherlands and Europe are some of the most prosperous parts of the world. Looking 100 years ahead is possibly a luxury many people in low- and middle-income countries cannot afford.

By answering these questions, this study aims to place the NL2120 and EU2120 reports in a global, and LMIC context. This is done as follows; first, how does the 2120 methodology compare to that of an already globally applied heuristic tool. Evaluating the 2120 approach against that of the nature futures framework (NFF) determines whether and how it can more generally be applied. Second, the study then looks at broad-based trends and drivers of climate change and biodiversity decline. Given how these trends differ across different geographies around the world, this highlights how the 2120 approach would have to adapt to very different contexts outside of Europe. Lastly, there are currently many nature based solutions initiatives already being implemented around the world. The 2120 approach (together with NFF) can add value to these through scenario work which illustrates how these wide-ranging initiatives can strengthen, or clash, with one another. This suggests that more collaborative governance is required. Just transitions is an important element in this.

This study is based on review of literature and datasets, attendance and discussions during the Earth Systems Governance 2023 and Waterproof 2024 conferences[1], and semi-structured interviews with experts and practitioners. It is intended to contribute to the broadening practice of nature-positive futures work, and provide discussion on how the methods applied to these two 2120 reports can contribute to wider scenario work.

1 Radboud Conference 2023 on Earth System Governance and Partners for Water: WaterProof 2024.

Netherlands 2120 and Europe 2120 maps

2020

2120

Box 1. Defining nature-based solutions (NBS)

NBS play a vital role in achieving a healthy biosphere and have the potential to address multiple global sustainable development challenges simultaneously. Instead of relying solely on technology or man-made interventions, these solutions harness the power of natural ecosystems and processes to address various challenges. According to the International Union for Conservation of Nature (IUCN), NBS are "actions to protect, sustainably manage, and restore natural and modified ecosystems, benefiting people and nature at the same time".

Besides actions, NBS are also an approach and strategy. NBS strategies and solutions should be tailored to specific local and regional circumstances. Policymakers and practitioners must carefully consider the synergies and trade-offs associated with NBS when designing strategies for climate change and biodiversity conservation. Drawing from Seddon(Seddon, 2021), four science-based guidelines are set out that optimize the role of NBS and which will ensure sustainable benefits to society;

- Are complementary, not a replacement, to the urgent phase-out of fossil fuels;
- Should encompass a wide range of ecosystems, both on land and in the sea;
- Require the active engagement and consent of diverse societies, respecting their cultural and ecological rights; and
- Should be purposefully designed to deliver measurable benefits for biodiversity.

Framing NL2120 and EU2120 in the Nature Futures Framework

The Nature Futures Framework (NFF) is a heuristic tool developed during a series of IPBES[2] events and gatherings, focusing on a process of future making. Introduced in 2020, it has since been elaborated on and applied in various futures exercises and geographic and oceanographic contexts around the world.[3] As such it provides a useful framework to assess whether and how the NL2120 and EU2120 are fit for purpose for wider, and LMIC, nature-positive futures exercises. This is evaluated looking at four areas relevant for applying for nbs scenario exercises in other parts of the world[4]; inclusion, scalability, methodology and scope. An overview of the NFFs in box 2 while table 2 captures how the 2120 reports and NFF were developed.

Inclusion: a beacon or a net

The 2120 reports are relatively unique in providing fairly detailed geographic maps of a potential and, according to the makers, possible and desirable future wherein nature and water-soil systems are core. The choice of working towards one seemingly detailed, but far from complete, future – as opposed to multiple potential futures – was a conscious choice by those that developed it; the intention was to present an integrated map that looked authentic but on closer inspection still allows for stakeholders to largely shape it within a broader set of parameters. This allowed for people with a wide-ranging background and interest, from business owners to community members, to still identify with the map. By contrast the NFF focuses explicitly on recognising the diversity of formal and informal relations different people, communities and (economic) systems can have with nature, depending on their context and values, while illustrating that they/we still all exist within the same framework of nature.

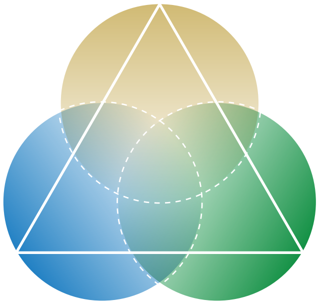
In this sense the two approaches complement one another; the 2120 reports develop one single, but flexible, vision which they expect will draw a diverse audience closer together, without specifying who that audience should include. This functions like a beacon. By contrast the NFF tool identifies diverse types of people by various characteristics and, rather than drawing them together immediately, helps them shape multiple nature-positive futures on the premise that this will help them recognise that they need to work together to make one or more of those futures come true. It functions like a net. So, while each method differs in how it aims to include diverse stakeholders, both ultimately work towards the same objective of inclusive collaboration.

2 Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. https://www.ipbes.net/
3 A library of NFF resources is maintained here.
4 References to the 2120 reports are derived both from the two reports themselves as well as a series of interviews conducted with Bertram de Rooij and Dr Tim van Hattum, two of the lead authors. NFF descriptions come from literature review and an interview with Dr Laura Pereira, one the IPBES taskforce members that developed it.

Box 2. The Nature Futures Framework and Three Horizons tools

NFF. The triangle on the right-hand side is the NFF framework, illustrating the three values or areas in which people relate to nature, derived from a series of international IPBES workshops. These cover intrinsic, instrumental and relational values of nature. This has been developed to make the values actionable for scenario and modelling work.

Three Horizons. A simple, graphical and collaborative approach to build pathways for desirable futures based on a structured and guided dialogue considered along a temporal axis (now, near future, and far future): the first horizon is a business as usual scenario, the second horizon represents the necessary actions to move from the present to the desired future and the third horizon represents emerging paradigms, ideas and innovations for a desirable future. This tool is often used in NFF, as a way to develop pathways/scenarios.



Source: (Pereira et al., 2020).

Scalability

The NFF is explicitly designed with an aim to be multi-scalar (Pereira *et al.*, 2020) and since its inception has been applied at different scales and contexts – as evidenced in the NFF library resources literature list (link available in table 2 under results). The methodology developed for the NL2120 exercises and mapping does not explicitly reference scalability, though it is referred to at the end of the EU2120 report. More to the point however, the capacity to scale is illustrated by first working at national Netherlands level and thereafter at both municipal and regional levels within the country[5], and at continental European level – meaning it can be scaled up or down depending on the needs and interests of different audiences. Whereas the 2120 exercises do not explicitly discuss scalability, their entry points are five principles and conditions, which are slightly adapted to the relevant scale and challenges at hand. Table 1 provides an overview of the framing of the two 2120 reports; while the process is the same, the principles and conditions are adapted to the scale of the landscape. In addition, the delineation of the regions are in both cases based on eco-regions, even though in practice the delineation and regional breakdown may differ (based on scale).

Table 1: framing and design of the 2120 maps and explanatory narratives

	Five principles	Five conditions	Regional breakdown
NL2120	• The natural system as a starting point • Nature-inclusive society • Circular economy • Adaptive spatial planning • Optimal use of water	• Blue-green landscape • Circular agriculture • Biobased economy • The city • Policy	• The north sea • The coast • Wadden sea • Southwestern delta • Northern clay soils • Peat soil grasslands • River areas • Ijssel lake • Higher elevation sandy soils • Urban environment
EU2120	• A healthy biosphere as the cornerstone • Nature-positive society • Climate-positive and circular economy • Adaptive and resilient • Inclusive and just	• Healthy water and soil • Regenerative food and primary production systems • Climate positive and circular bioeconomy • Green and liveable cities • Connected resilient nature	Ecoregional clusters: • *North*: the Arctic and Boreal region • *West*: the Atlantic and North Sea region • *East*: continental region • *Central*: Alpine and Pannonian region • *South*: Mediterranean region

5 Subsequent workshops and studies led by WUR have been applied in the town of Arnhem, the Veluwe valley and Rivierenland (the part of the Netherlands through which the three main rivers flow).

Nature positive futures methodology

Table 2 provides a concise overview of the methodology for each of the 2120 reports, and the different methods applied under the NFF framing. The 2120 approaches apply many of the methods that have been applied using NFF, namely visioning and modelling – which were required for the mapping – and scenario narratives, which make up the accompanying report. Interviews with the lead authors also illustrated that many of the principles adopted for especially the EU2120 report overlap with the values described within the NFF triangle. In practical terms, the design exercise of the 2120 reports and the NFF itself follow a similar approach; starting with a relatively small expert group to frame the exercise focus, then inviting a wider array of stakeholders to input for the scenario – and with some of the NFF exercises, the pathways – followed by a smaller group translating the raw results into a concise set of visuals, narrative, etc. Moreover, the lead authors agree that the approaches are flexible and not set in stone. Neither approaches have a specific definition of what 'inclusive' means or how to ensure inclusion.

The ways in which the two meaningfully differ are threefold; first, the 2120 reports focus on one desirable future, while the NFF looks at multiple desirable futures. Second, the 2120 reports are more visual and spatial based, e.g. developing a semi-detailed map and building a narrative around this. The NFF instead, albeit sometimes using visuals, focuses on describing the different relationships between people and nature, thereby emphasising value based narratives. Third, applications of the NFF often develop visions and pathways to get there, while the 2120 reports 'just' do the visioning exercise; applications of the NFF frequently includes utilsation of the Three Horizons tool (see box 2 for definition) for identifying pathways. A part of this tool involves identifying current drivers in its first Horizon (Pereira *et al.*, 2020). It is used as a stepping stone to identify what actions or policy interventions are needed to support transitions and overcome obstacles. This is consciously absent in the 2120 reports; while the maps and scenarios were developed on the basis of what the participants thought was possible and desirable, the current drivers themselves are not referred to. Instead, identifying and unpacking these drivers as a first step to developing pathways is expected to be done in subsequent exercises with stakeholders. These exercises have subsequently been done in the Netherlands, though not as yet at European scale.

Table 2: overview of methods and results

	Netherlands 2120 Published 2019	**Europe 2120** Published 2023	**Nature Futures Framework** Published 2020
Objective, timeline & method	Define a probable scenario of what the Netherlands could look like in 2120 if it used an integrated water-soil system and nature-based solution as its basis. Team of around 20 experts from different backgrounds (Wageningen Economic, Environment and Marine Research depts) coordinated by core group to develop an integral vision of the Netherlands in 2120. The discussion/workshop was split into 3 series to answer 3 questions; • What is the current state of play? • What is the main challenge? • What are the potential pathways? This was then translated into a narrative and subsequently an accompanying visionary map – developed to be reasonably specific but not overly detailed, and so act as inspiration and guidance but without being overly prescriptive.	Expanding on NL2120 result and process, define a probable scenario of what Europe could look like in 2120 if it used an integrated water-soil system and nature-based solution as its basis. Three design cycles that built upon one another; 1. Core group of WUR experts determined major characteristics, issues, design principles and nature based strategies. 2. Two-day workshop with 45 international students to further detail out five identified ecoregional clusters across Europe. 3. Core group of WUR experts + designers shaped results into narrative and visual (e.g. maps and report).	Apply different methods using a heuristic tool that can frame a plurality of perspectives on desirable nature-based futures, has multiscale functionality, and so allows for standardised comparison and collaboration of different approaches across geographies. The NFF was developed between September 2017 – May 2019, and has since been shared and applied many times, through which its methodology is evolving. Five methods for using the NFF are described in IPBES 2023 as well as combinations of these; 1. Identifying common and specific features and scenarios families. 2. Visioning and storyline of desirable nbs-positive future. 3. Defining pathways (3 horizons). 4. Scenario narratives (e.g. qualitative). 5. Modelling. 6. Indicators.
Results	• Visionary NBS map of the Netherlands in 2120 • Accompanying explanatory report of the vision underlying the map • Link to report	• Overall map + maps of 5 bioregions, with accompanying explanation • Presentation & discussion of findings to technical experts and parliamentarians in Brussels • Link to report	• Heuristic NFF tool development here (2020) and methodology described here (2023). • Six scenario 'skeletons' based on NFF (2023). Report here. • Application of NFF tool in different scenarios. Library of resources here.

Scope

The 2120 reports are very much conscious of appealing to a wide audience, which especially includes policy-makers. In the NL2120 report, policy is one of the five conditions mentioned, while in the EU2120 report the vision laid out is framed as an opportunity for Europe to "take on a leadership role for present and future generations by championing climate and biodiversity action on the global stage"(Hattum *et al.*, 2023). However, neither 2120 reports mention the impact of the Netherlands or Europe's existing or future policies on other parts of the world. By contrast the objectives of the NFF tool is not just to capture the variety of values that different actors have in a focus region, but also to both compare and contrast between regions, and most significantly, identify connections between different regions; "[c]omparison of such case studies can also be used to identify shared drivers, and ignored or hidden teleconnections between local places. This type of comparison is necessary to ensure that global analyses adequately identify the cross-scale dynamics that are shaping the world"(Pereira *et al.*, 2020). In other words, if Europe truly wants to be a global leader in nature positive futures, taking into account how its policies impact other parts of the world – through telecoupled flows such as trade, finance or regulations – would need to be included in its mapping, and not stop at its physical borders.

Historical drivers and future trends

Identified drivers are the basis for developing pathways towards potential futures (Steffen *et al.*, 2015). While the 2120 reports implicitly address these as part of their vision, the Netherlands and European exercises consciously did not look at how to shift current-day behaviours and attitudes. A number of NFF exercises have done this on the other hand. Moving beyond a European context it is important to understand what drivers exist globally, but also how they differ within regional and socio-economic context for LMICs.

This section unpacks some of the broad-based drivers and trends around nature. It draws on the 'Great Acceleration' debates and specifically the 2015 paper 'The trajectory of the Anthropocene: The Great Acceleration' (Steffen *et al.*, 2015). This paper updates the originally published earth system trends graphs (Steffen *et al.*, 2005) to 2010 (and which go back to 1750) and, more importantly, disaggregates the socio-economic trends between wealthier and poorer countries. This section draws on this approach by, first, disaggregating drivers between wealthier and poorer parts of the world, and second, distinguishing between climate change and biodiversity trends as the two interrelated but functionally different parts of nature. It also identifies linkages, or telecoupling, between different parts of the world and, based on these historical drivers, hypothesizes some potential future trends.

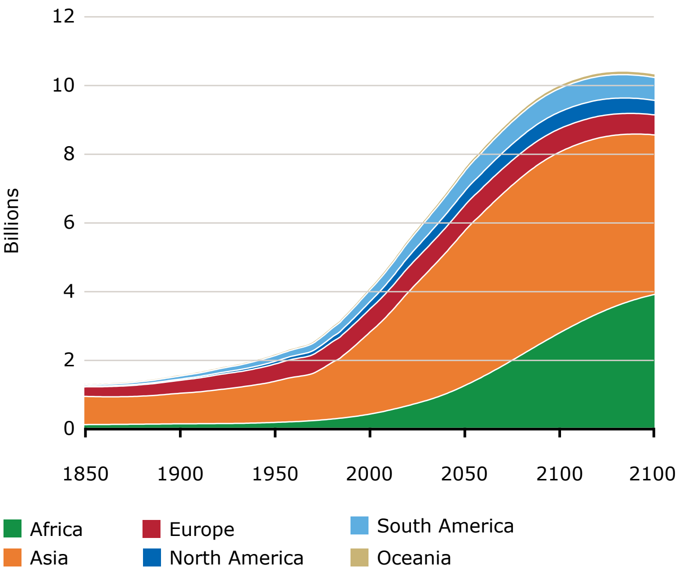
Global CO_2 emissions are driven by wealth and consumption, not population growth

The enormous shifts in industrial and technological developments have managed to better feed, extend life expectancy and improve quality of life for an increasing amount of an already burgeoning human population than at any point in human history (Pinker, 2018). And while this of course differs by continent, almost all indicators of human wellbeing have steadily increased over time since the second half of the 19th century.[6] Since the early 1950s, the global population has boomed, going from 2.5 billion in 1950 to surpassing 8 billion in 2023. This has been driven first by Asia (and especially China and India) though the African continent has since picked up pace. All other continents have notably not contributed to this almost at all. Graph 1 illustrates this global and continental growth, and includes the forecast peak at about 10.5 billion towards the end of this century. And while this is an estimation, what is certain is that Asian and African countries will, by far, make up the greatest amount of people in the world.

However graph 2 indicates that, though CO_2 emissions have increased since the 1950s, it is correlated with GDP growth worldwide. These two variables are commonly recognised as being linked to one another and indicate the high dependency the global economy continues to have on

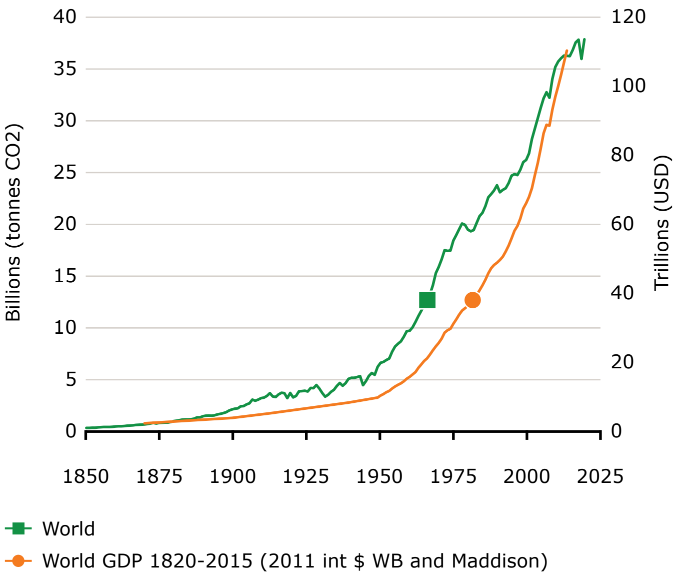
6 Our World In Data, (Life Expectancy - Our World in Data).

Graph 1 Population growth 1850-2100 (including forecast).



Source: Our World In Data.

Graph 2 CO_2 emissions (left axis, green line) and GDP (right axis, orange line).



Source: Our World In Data, Annual CO_2-emissions by region and World gdp over the last two millenniapopulation growth.

fossil fuels. Regional-specific data confirms what these broad-based trends suggest, namely that as of 2020 high income countries are responsible for just under 40% of global CO_2 emissions while making up about 16% of the world's population (a ratio of 2.48) while low and middle-income countries make up 56% of global CO_2 and 84% of the global population (a ratio of 0.67).[7]

Telecoupling: importing goods while 'exporting' impact

CO_2 (and other GHG) emissions cannot simply be measured within the boundaries of countries' borders. Graph 3 shows that emissions in Asian countries have steadily risen since the 1960s, and most notably in China since 2001, the same year it joined the World Trade Organisation. By contrast, European and North American trends both show a tabling and then curving down – which seemingly contradicts the second graph's correlative link between wealth and emissions. Further to this, measuring CO_2 per capita rather than tonnage, the US has actually been in decline since the early 1970s and Europe since 1990.[8]

Graph 4 however captures emissions by region based on trade – in other words, if a product is bought and used in one country, the CO_2 emitted to produce this good are allocated to the consuming country and subtracted from the producing country (on the rationale that production of goods are demand-driven and so the consuming country is responsible for the emissions). In graph 4 this is illustrated along an axis whereby positive values (above the x-axis) indicate a net import of CO_2 emissions while negative values (below the x-axis) indicate net export. Adding up European and North American figures (the light red line) results in a trend that does not mirror, but mimics, China's net negative CO_2 emissions by trade (the dark red line) – an indirect relationship that emerges in 1993, and 'jumps' in 2001 (since China joined the WTO). This trend in part reflects the globalisation of trade and China becoming the 'factory of the world'.

7 These figures take trade into account. Note that total emissions don't add up to 100%, which is because "[t]he emissions shares of lower-middle and especially low-income countries could be slightly underestimated; this is because consumption-based emissions cannot be calculated for some poorer countries due to poor data availability." Sourced from (Global inequalities in CO_2 emissions - Our World in Data).

8 Our World In Data, (Per capita CO_2 emissions, 2022).

Box 3. Telecoupling

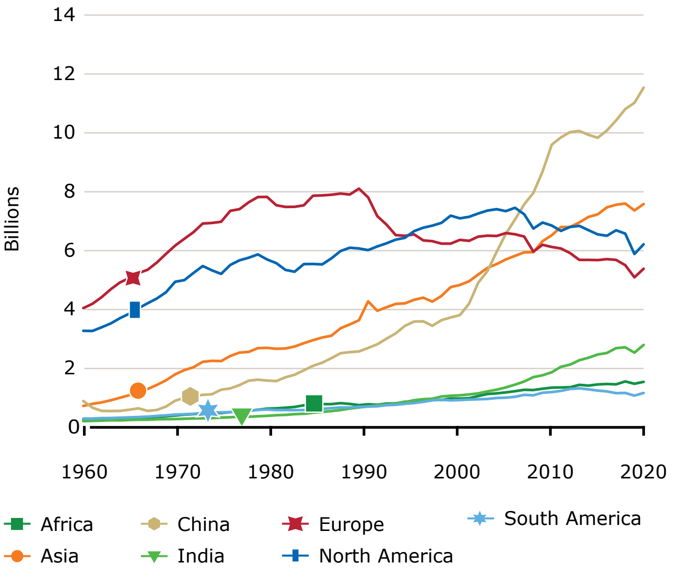
Telecoupling refers to the connection between one landscape or space with another distant landscape or space. Such connection can be made in different ways, such as energy, finance, trade, people, information, governance or wellbeing, and at different temporal or organisational scales (IPBES, 2018; Hermans *et al.*, 2023). The reason for explicitly using a term for these type of distant connections is the common practice of overlooking these connections in accounting for impact (e.g., biodiversity or CO_2 impacts). In the context of LMIC, these connections are, however, very important for visioning sustainable futures or NBS, since a sustainable vision one place may have consequences for other places.

What this illustrates is a telecoupling between disparate countries and regions through trade, together with a lack of trade agreements on the environmental impact of this trade. If Europe (and the US) want to meaningfully lower their carbon footprint, they have to address the means of production of the goods they consume domestically, but are produced internationally. As the above examples shows, the costs of CO_2 emissions can be outside the country which actually drives the CO_2 emissions. The increase in telecoupled markets is also a major driver of land use change, particularly of deforestation in LMICs (Ordway, Asner and Lambin, 2017; IPBES, 2018). One example is a case study in UNEP's 2022 'State of Finance for Nature' report, which shows that massive deforestation over the last 30 years in Ivory Coast is driven by cocoa expansion, which is needed for private income and public revenue, but is mainly destined for export to the EU. By changing the tariff structure to favour processed over raw goods, the EU can incentivize reinvestment into capital- rather than land-intensive production (UNEP, 2022). In general, the transferring of land use change (esp. cropland) from high income countries to LMICs is visible through the expanding proportion of croplands in LMICs that are used for consumption outside the production country (Yu, Feng and Hubacek, 2013). To this end, biodiversity decline in LMICs are also largely influenced or driven by telecoupling.

Biodiversity: declining ecosystem, species and genetic diversity

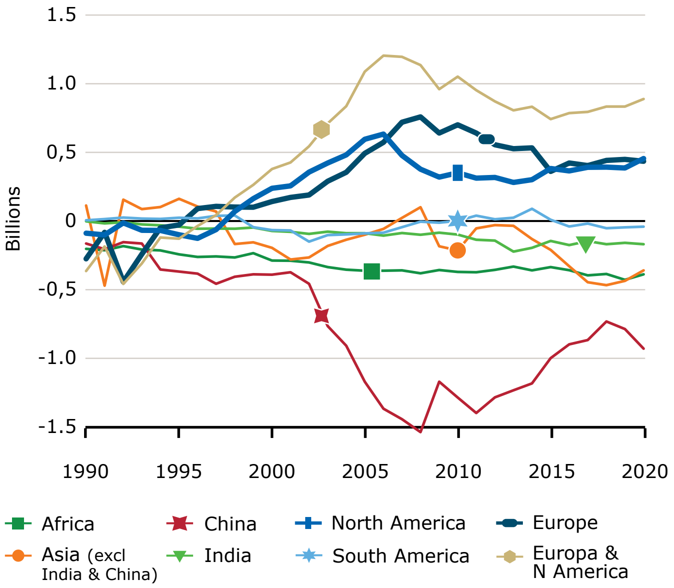
Unlike the relatively simple indicator of CO_2 for climate change, biodiversity remains much more challenging to define and delimit. Understanding biodiversity trends on a global or continental level is therefore quite challenging because of the multitude of indicators across the different types of biodiversity, the different scales and their interconnectedness. This is captured in box 4, which also differentiates between three scales, namely genetic biodiversity, species diversity and ecosystem biodiversity. These three scales can be used to get a better idea of biodiversity trends.

Graph 3 CO_2 emissions 1960-2020 (tonnes by region).



Source: Our World In Data.

Graph 4 CO_2 emissions in global trade net import-export balance in tonnes of CO_2.



Source: Our World In Data, Co2-emissions embedded in global trade.

Box 4. Defining biodiversity

Biodiversity, short for biological diversity, refers to the variety of life on Earth at all levels of biological organisation. It encompasses the variety of species of plants, animals, and microorganisms, the genetic differences among them, and the ecosystems they create and processes that support these. Biodiversity is foundational to the functioning of ecosystems, which in turn provide vital ecosystem services such as pollination, nutrient cycling, and water purification. In addition, biodiversity also has important cultural, economic, and aesthetic value, and is a source of inspiration for culture, art, music, literature, and religion.

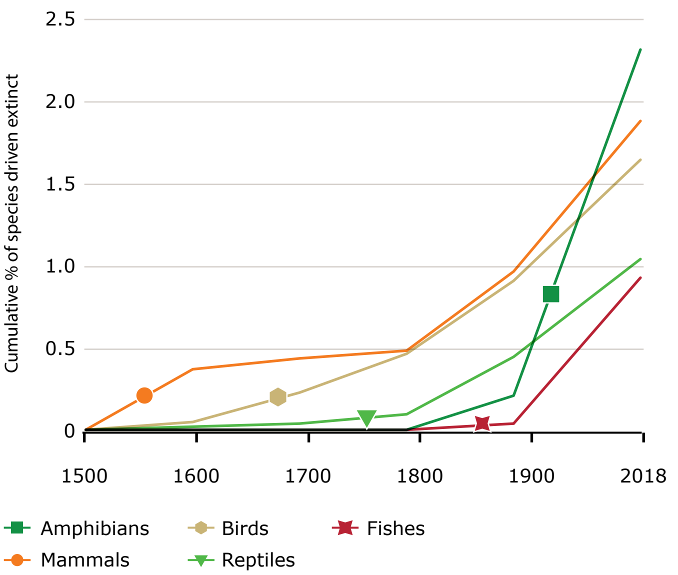
The convention on Biological Diversity signed at the United Nations Conference on Environment and Development in 1992 defines biological diversity as 'the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems' (United Nations Environment Programme, 1992). Since this definition in 1992, the concept of biodiversity has continously developed, and currently many different, largely overlapping definitions exist. A common definition descrbes it as the variety and variability of living organisms, their habitats and their contribution and role in the ecosystem processes. An alternative definition focuses on biodiversity as the total of ecosystems, species and genetics within a region or the whole planet (Maclaurin and Sterelny, 2008). Biodiveristy is complex and operates on different levels, therefore it is often divided into three components:

1. **Genetic diversity** – referring to the variation in genes within a species.
2. **Species diversity** – referring to the variety of species in a particular region or ecosystem.
3. **Ecosystem diversity** – referring to the variety of habitats, ecological communities, and ecological processes in the biosphere.

Due to biodiversity encompassing so many different elements, many indicators can be chosen depending on the context, scale and system. In addition, impact on biodiversity is also often illustrated by considering the direct drivers of biodiversity loss. These drivers have a direct and immediate impact on the composition, structure, and functioning of ecosystems and include; habitat loss and degradation, resource extraction, pollution, climate change, invasive species, diseases and parasites, fragmentation and connectivity loss (of habitats), and land/sea- use change (IPBES, 2019).

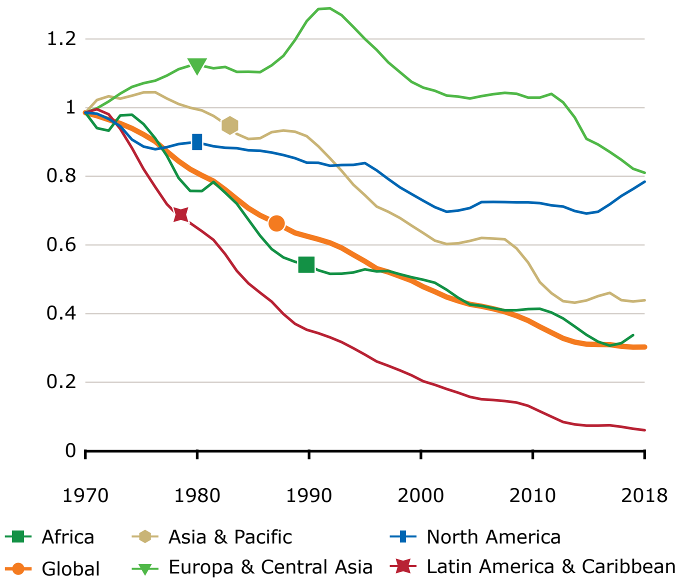
Of the three components of biodiversity, **species diversity** data goes back the furthest in terms of historical trends. While landscape transformation and agriculture has been the defining quality of human history, (Erlandson and Braje, 2013; IPBES, 2019) it is not since the industrial revolution and associated population growth that larger scale domestication of land has begun to systemically impact biodiversity, with almost 90% loss for European and North American areas since 1800 (Biro, 2018). The second world war in Europe was followed by the Green Revolution driving further agricultural intensification, triggering a steep decline of species in agricultural

Graph 5 Vertebrate species trends by type 1500-2018 years.



Source: IPBES (2019)

Graph 6 Vertebrate species trends by continent 1970-2018.



Source: Living planet index (LPI) per continent as retrieved.

habitats and increasing invasive species (Krausmann *et al.*, 2013). This trend is illustrated in graph 5 with land-based vertebrates beginning to decline since the 1800s while fish and amphibians begun to decline since the start of the 20th century.

As shown in graph 6, more detailed data captured since 1970 confirms this continued species decline globally (the solid blue line) with a 69% decrease over 50 years. There is considerable variation by continent, wherein North America and Europe & Central Asia have shown the least decline, while decline in global south countries are far greater. That Western countries have shown a relatively small decrease is more likely because the baseline of species diversity was so low since the start of measurement, and only those species populations remain that are best adapted to living alongside humans (Westveer, Freeman and McRae, 2022).

Available evidence of **genetic diversity** illustrate a similar picture as that of trends in species diversity; The FAO reports that in the past 100 years nearly three-quarters of genetic diversity has been lost (FAO, 2020). This has been driven by processes such as domestication, standardisation and intensification of food production (Tuxill, 1999; Pilling, 2010). Since the 1960s, it is estimated that countries like China and India have lost thousands of landraces of rice, while Mexico has lost more than 80% of its maize diversity (Tuxill, 1999).

Considering **ecosystem diversity**, biodiversity hotspots[9] are similarly declining; many of these hotspots are located in LMICs, making their role in preserving and/or restoring these areas even more important. In the areas of terrestrial hotspots of species rarity, there is a more rapid decline in ecosystem structure (35.5% primary vegetation with a -5.1% loss per decade of the 1970 level) than by comparison to global trends (39% primary vegetation and -4.1% loss per decade). The percentages for 'land neither cultivated nor urban' are also worse in hotspots (71.7% and -0.6% per decade) than global (76.7% and -0.2%, respectively) ('Land Cover CCI Product User Guide Version 2.0.', 2017; IPBES, 2019). In addition the biodiversity habitat index[10] is only 58% for rarity hotspots compared to 70% global. The consequences are in line with the Red List index, showing the extinction risk of species between 1993 and 2023 has mainly increased in Sub-Saharan Africa, Asia and Latin America and the Caribbean.

Many of the drivers of biodiversity loss have also accelerated rapidly (IPBES, 2019); while there are a number of key drivers that impact biodiversity, "land/sea use change (mainly in the form of rapid expansion and intensifying management of land used for cropping or animal husbandry), and direct exploitation (mostly through fishing, logging, hunting, and wildlife trade) have been the two dominant drivers of global biodiversity loss overall over recent decades"(Jaureguiberry *et al.*, 2022). Looking at changes in land use since 1750, loss of tropical forests has been steadily increasing and does not show any sign of abating. For Africa, Asia Pacific and Latin America & Caribbean, an acceleration in the increase of agricultural area use for crops and grazing has taken place since the 1950s,(*Agricultural area over the long-term*) and since then has begun to table off, most likely explained by the decrease in available arable land and the intensification of agriculture (as opposed to expansion) (Steffen *et al.*, 2015).

Overall there are two notable phases in the rate of land use change globally; first, an acceleration between 1960 to 2004, followed by a decrease from 2005 to 2019 (Winkler *et al.*, 2021). The acceleration can be connected to the agricultural intensification in the 1960s driven by the green revolution, to the focus on globalised market production and increasing global trade during the 1990s. This acceleration is more visible in LMICs since the 2000s, where both the production and exports increased, (Winkler *et al.*, 2021) and so contribute to an acceleration of biodiversity loss.

Estimating future trends

Given the description above, there are three interrelated broad-based trends that have driven the impact on the environment and biodiversity to-date. Understanding whether and how these trends will shift in the future will be key for countries around the world to enable a future that includes nature based solutions.

The **global population** will continue to grow until the latter half of the 21st century and then table off. The African continent is the main driver of this, as Asian countries are already ageing along with Western countries. If this trend continues, by the end of the century Africa itself will have become an ageing continent, and without a greater push in other parts of the world for greater reproduction, the global population will begin to decline. Countries wherein the aged and adolescent outweigh the

9 Biodiversity hotspots are areas with high levels of species diversity, including endemic species and/or endangered species.

10 Uses biologically-scaled environmental mapping and modelling to estimate impacts of habitat loss, degradation and fragmentation on retention of terrestrial biodiversity globally from (Hoskins, 2020).

working population face constraints on their economic growth under current models. Whether the impact of this trend will be good, neutral or bad for the climate and biodiversity will depend in part on the size of the population, but more importantly on their consumption patterns and whether these can be decoupled from increased CO_2 emissions and land usage.

Wealth and consumer preferences are the greater driver of both CO_2 emissions and biodiversity loss, though in different ways. Moreover, there is a much clearer correlation between consumption and emissions versus consumption and biodiversity loss. As economies grow and develop across LMICs, broadly speaking they have followed similar natural resource extractive trends as wealthier countries. Given this, for CO_2 emissions and biodiversity the following forecasts can be made;

- There are weak signals that wealthier countries have begun to be able to decouple economic growth from **CO_2 emissions** (beyond simply exporting them). There is also some evidence that developing economies in the global south are doing the same, though these are generally exceptions to the norm. Given that the poorest continent is also the youngest it is likely that many African countries will benefit from their demographic dividends up until the 2050s. Many of these in turn will increase their CO_2 outputs directly (e.g. domestically) or indirectly (through imports), though it is also likely that their per capita CO_2 output will not match that of European countries given efforts for alternative/renewable energy sources.
- **Biodiversity** itself has a broad definition and is affected by multiple factors. Nevertheless, almost all indicators show that it is in decline and there is little sign that this is meaningfully changing. Wealthier countries that have a longer history of decimating biodiversity within their geographic borders will likely do better in managing the multiple drivers, though with mixed results. Developing countries have a greater opportunity to maintain what they already have – though the pressures of agricultural expansion and natural resource exploitation will make this very challenging. The likelihood is greater that biodiversity will continue to decline in most parts of the world before it starts to improve.

The world has been inextricably **telecoupled** through complex natural processes (e.g. global ecosystems) that long predate the emergence of modern humans. Human trade, transport and financial flows begun expanding in earnest since the 15th century, and especially in the 20th century have globalised the flow of goods and services. While the shape of globalisation will change in the 21st and start of the 22nd century it will not recede. All countries around the world import and export food and goods, which means that all countries influence carbon emissions and biodiversity beyond their own borders. In the coming years this will likely become more, not less, complex as more countries around the world diversify their consumption patterns through increased wealth. For nature-based solutions to meaningfully succeed, telecoupled linkages to otherwise far-flung parts of the world will need to be taken into account.

Towards governing nature positive futures in different contexts

Given the existing and potential future trends for CO_2 emissions and biodiversity, there is an enormous need to address the drivers at all levels – locally, regionally and globally. Many initiatives are already taking place on the ground at every level in all parts of the world. The 2120 approach can potentially add value to this and, more importantly, help steer much-needed governance mechanisms to navigate between differing human and planetary needs today and in the future. This section begins a discussion on this.

Connecting Nature-based initiatives and futures exercises around the world

The first part of table 3 highlights databases and projects that include reference to hundreds of nature-based initiatives on every continent in rural, peri-urban and urban areas. The second part highlights two databases of future scenario exercises looking at nature-positive change. Since the NFF's launch, it has been applied hundreds of times in different contexts in richer and poorer countries, across the oceans, globally, and continually – including in Europe. On its part, NL2120 has prompted dozens of local- and regional-level initiatives, including of course at continental scale. Suffice it to say, there are many current and future initiatives already ongoing around the world.

A combination of the 2120 approach and NFF can add value to especially the ongoing initiatives by providing mechanisms to improve collaboration between them. Mapping existing and future potential ecoregional clusters, as conducted in the Europe2120 report, around the world based on future trends is one way of illustrating what collective efforts could look like. This could also be applied using the NFF tool which would unpack multiple future ecoregional clusters and pathways for the same region. These kinds of multistakeholder exercises themselves could be part of strengthening collaboration and establishing governance mechanisms in areas where they are weak, absent or cross over borders.

Table 3. Nature-based initiatives databases and studies (non-exhaustive)

Nature-based databases & projects	• NBS initiative: database of 150+ nature-based solutions cases mapped around the world and categorised under different nature indicators. • Urban Nature Atlas: database of 1000+ nature-based solutions oriented towards urban contexts around the world, categorised under different nature indicators. • Conexus: EU-funded project connecting European and Latin American cities to co-develop nature-based solutions and ecosystem restoration. • Seeds of Anthropocenes: database of nature-positive initiatives around the world, intended to spark 'good anthropocenes' or futures that are socially and ecologically desirable. • NBS knowledge database: a database of European research, policy, projects and market-based tools applied worldwide by Network Nature.
Nature-positive futures resources	• NFF literature database: repository of reports, publications and materials that have applied the IPBES nature futures framework at different scales and contexts. • Biosphere Futures: Database of nature-positive scenario exercises conducted by researchers and practitioners from around the world.

Just transitions in different socio-economic contexts

As the plentiful applications of both NFF and 2120 illustrate, there is no shortage of interest in nature-positive opportunities, and the cases are incredibly varied given the non-universal and fairly flexible definition given to nature (though, in reference to the three categories in box 2, most initiatives and scenarios tend to orient around species and ecosystem diversity and less around genetic diversity). What is also clear is that nature preservation and restoration is by no means a 'global north' agenda. The consequences of the potential loss of biodiversity on economies and livelihoods is reflected by the fact that "55% of global GDP is moderately or highly dependent on [biodiversity and ecosystem services]"(Schelske *et al.*, 2020). The challenge therefore does not lie with the motivation for the development of nature positive initiatives and futures, but how these can be done without giving up on human development goals. To this end, the transition to newly developed nature futures needs to be a 'just transition'.

Just transition is a commonly used term in the climate change debate in referring "to meeting climate goals by ensuring the whole of society – all communities, all workers, all social groups – are brought along in the pivot to a net-zero future"(UNDP, 2022). The presumption, or hope, implicit in the just transition concept is that the synergies are greater than the trade-offs for even the most disadvantaged in society – or in other words, that by transitioning to a carbon neutral (or carbon negative) based economy this will simultaneously address societal inequities. Such a conditioned transition is also relevant in the biodiversity discussion, based on for example IPBES discussions (IPBES, 2022). Measures for nature-positive futures, therefore, have to take human development into account.

Both the NFF and 2120 approaches implicitly or explicitly adopt the aspiration of just transition, e.g. that a nature based solution is socio-economically inclusive; in the EU2120 report one of the five principles is 'inclusive and just'. Similarly, in the NFF and various applications of it, the SDGs are often referred to, suggesting that a win-win solution is being aimed for. However, global level studies show mixed results in terms of whether the 2030 SDG targets are synergetic or force trade-offs; for example, Kroll (Kroll, Warchold and Pradhan, 2019) indicates that some targets complement one another while others mean prioritisation of one over another is required. Similarly, Dzebo (Dzebo and Shawoo, 2023) illustrates that the SDGs can overall support the 1.5c global temperature limit objective, but that some targets conflict with one another. As such nature positive futures will need to be explicit about synergies, and potential conflicts.

Governance mechanisms that identify overlapping areas of synergy and trade-offs between different future scenarios is not yet so evolved. There are a number of reasons for developing this; first, with an emergence of so many initiatives around nbs there is the potential that the spillover of one initiative adversely affects other geographies in the medium to long term. For example, rewilding landscapes in one area while importing more food from another is simply shifting the problem. Second, the needs and wants of disadvantaged people across poorer parts of the world are different from those in countries whose social safety nets and financial reserves are greater. While Just Transitions remain a challenge in all countries, they are especially acute in many low and middle income countries. As successful and appropriate nbs may differ per context, this needs to be reflected in the nature positive futures approach.

Conclusions and recommendations

The following can be said about adapting the 2120 approach for international and LMIC context;

- The 2120 approach overlaps, and is compatible with, the NFF, a heuristic tool that has been applied in multiple contexts and different scales globally. Integrating the two can enrich both approaches – one focusing on water-soil systems (spatial based), the other on human relations to nature (value based).
- Due to differing historical political economic trends, human impact on climate and biodiversity differs radically, as do human relationships with nature, around the world. Furthermore, the impact is not geographically bound because of trade, finance and other relationships that trigger telecoupling, e.g. linkages across disparate geographies. These need to be included more explicitly in nature positive futures thinking.
- While there is a recognition of human impact on climate and nature, and a policy potential to change this to create more synergetic change in the long run, short term drivers (from needs such as poverty/inequality reduction, to wants like more lifestyle choices) are impeding this. Addressing this will be foundational for pathway development.
- There are already many ongoing nbs initiatives and nature positive scenario work. Applying a 2120-NFF integrated approach in the same geographic areas should build on, rather than replicate, these initiatives.
- Just transitions, especially in LMIC contexts, requires much greater governance mechanisms to manage and navigate the trade-offs and tensions between human and nature needs.

Given this the following recommendations are given;
The 2120 approach has already catalysed investment into nbs within the Netherlands, contributed to nbs initiatives at European scale, and its potential application is already being explored in Australia through an initiative run in parallel to this study. It has the potential to do so in LMIC contexts given its flexible and scalable approach, though it should be integrated with the NFF as a tried-and-tested heuristic tool that focuses more on human relations to nature and so complements the integrated water-soil system approach. This alignment can further develop the methodology to take into account telecoupling, trends and drivers, and consider multiple future maps which make more explicit people's differing relationships to nature which the NFF highlights. In addition, it can provide guidance for the process of pathway development as a next step from vision development on which 2120 now focuses.

Given the variety of ongoing initiatives there's potential to not just map future scenarios based on existing work, but develop and improve collaborative governance between these initiatives. This means building out the methodology to include tools for pathways development, translating the scenario work into more practical actions that are viable and properly resourced. Geographical regions that have similar characteristics will likely result in pathways with commonalities, allowing these regions to learn from one another.

Just transitions need to be particularly well managed in LMIC contexts given the short term needs of more marginalised people in the absence of social safety nets. Scenarios needs to acknowledge and make this explicit to avoid the risk that these groups do not endorse these potential futures, or that they become (further) exploited by them.

Integrating the two methodologies should be done through practical application in a specific LMIC context. These should be selected based on willingness of local stakeholders to be involved in running the exercises and process, and adopting and applying the results.

Acknowledgements

We would like to thank the following people for providing feedback: Bertram de Rooij, Tim van Hattum, Laura Pereira and Jeanne Nel. This study was carried out by Wageningen University & Research and was commissioned and financed by the Dutch Ministry of Agriculture, Nature and Food Quality within the context of the Knowledge Base programme 'Biodiversity in a nature-inclusive society'.

Doi nummer: 10.18174/656484

Bibliography

Agricultural area over the long-term, Our World in Data. Available at: https://ourworldindata.org/grapher/total-agricultural-area-over-the-long-term?time=1800..latest (Accessed: 1 March 2024).

ARNHEM2120 - Durf vooruit te kijken. Available at: https://www.arnhem2120.nu/ (Accessed: 2 March 2024).

Baptist, M. *et al.* (2019) 'A nature-based future for the Netherlands in 2120'. Available at: https://doi.org/10.18174/512277.

Biro, M. (2018) 'Use of long-term data to evaluate loss and endangerment status of Natura 2000 habitats and effects of protected areas', *ResearchGate* [Preprint]. Available at: https://doi.org/10.1111/cobi.13038.

Dou, Y. *et al.* (2023) 'Using the Nature Futures Framework as a lens for developing plural land use scenarios for Europe for 2050', *Global Environmental Change*, 83, p. 102766. Available at: https://doi.org/10.1016/j.gloenvcha.2023.102766.

Dzebo, A. and Shawoo, Z. (2023) 'Sustainable Development Goal interactions through a climate lens: a global analysis'. Available at: https://doi.org/10.51414/sei2023.010.

Erlandson, J.M. and Braje, T.J. (2013) 'Archeology and the *Anthropocene*', Anthropocene, 4, pp. 1–7. Available at: https://doi.org/10.1016/j.ancene.2014.05.003.

FAO (2020) *How the world's food security depends on biodiversity*. Rome, Italy: FAO. Available at: https://www.fao.org/documents/card/en/c/cb0416en (Accessed: 4 March 2024).

Global inequalities in CO_2 emissions - Our World in Data. Available at: https://ourworldindata.org/inequality-co2 (Accessed: 1 March 2024).

Hattum, T. van *et al.* (2023) *Imagining a nature-based future for Europe in 2120: nature-based solutions at the heart of a visionary approach for accelerating the transition to a climate resilient and nature-positive future*. Wageningen University & Research. Available at: https://doi.org/10.18174/637123.

Hermans, T. *et al.* (2023) 'Telecoupled landscapes for nature inclusive transitions: Conceptual framing and methods'. Available at: https://doi.org/10.18174/589178.

Hoskins, A.J. (2020) 'BILBI: Supporting global biodiversity assessment through high-resolution macroecological modelling', *Environmental Modelling & Software*, 132, p. 104806. Available at: https://doi.org/10.1016/j.envsoft.2020.104806.

IPBES (2018) *The IPBES regional assessment report on biodiversity and ecosystem services for Africa*. Zenodo. Available at: https://doi.org/10.5281/zenodo.3236178.

IPBES (2019) *Global Assessment Report on Biodiversity and Ecosystem Services*. Available at: https://www.ipbes.net/node/35274 (Accessed: 1 March 2024).

IPBES (2022) 'Methodological assessment of the diverse values and valuation of nature of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services'. Available at: https://doi.org/10.5281/zenodo.7687931.

Jaureguiberry, P. *et al.* (2022) 'The direct drivers of recent global anthropogenic biodiversity loss', *Science Advances*, 8(45), p. eabm9982. Available at: https://doi.org/10.1126/sciadv.abm9982.

Krausmann, F. *et al.* (2013) 'Global human appropriation of net primary production doubled in the 20th century', *Proceedings of the National Academy of Sciences*, 110(25), pp. 10324–10329. Available at: https://doi.org/10.1073/pnas.1211349110.

Kroll, C., Warchold, A. and Pradhan, P. (2019) 'Sustainable Development Goals (SDGs): Are we successful in turning trade-offs into synergies?', *Palgrave Communications*, 5(1), pp. 1–11. Available at: https://doi.org/10.1057/s41599-019-0335-5.

'Land Cover CCI Product User Guide Version 2.0.' (2017). European Space Agency. Available at: https://maps.elie.ucl.ac.be/CCI/viewer/download/ESACCI-LC-Ph2-PUGv2_2.0.pdf.

Life Expectancy - *Our World in Data*. Available at: https://ourworldindata.org/life-expectancy (Accessed: 1 March 2024).

Maclaurin, J. and Sterelny, K. (2008) *What Is Biodiversity?* University of Chicago Press.

Ordway, E.M., Asner, G.P. and Lambin, E.F. (2017) 'Deforestation risk due to commodity crop expansion in sub-Saharan Africa', *Environmental Research Letters*, 12(4), p. 044015. Available at: https://doi.org/10.1088/1748-9326/aa6509.

Per capita CO_2 emissions, 2022. Available at: https://ourworldindata.org/grapher/co-emissions-per-capita (Accessed: 1 March 2024).

Pereira, L. *et al.* (2020) 'Developing multiscale and integrative nature–people scenarios using the Nature Futures Framework', *People and Nature*, 2. Available at: https://doi.org/10.1002/pan3.10146.

Pilling, D. (2010) 'Threats to animal genetic resources for food and agriculture – approaches to recording, description, classification and analysis', *Animal Genetic Resources/Resources génétiques animales/Recursos genéticos animale*s, 47, pp. 11–22. Available at: https://doi.org/10.1017/S2078633610000986.

Pinker, S. (2018) *Enlightenment Now: The Case for Reason, Science, Humanism, and Progress*. Available at: https://www.bol.com/nl/nl/f/enlightenment-now/9200000080338513/ (Accessed: 27 February 2024).

Schelske, O. *et al.* (2020) *Biodiversity and Ecosystem Services A business case for re/insurance*.

Seddon, N. (2021) *Guidelines for successful, sustainable nature-based solutions.*

Steffen, W. *et al.* (2005) *Global Change and the Earth System: A Planet Under Pressure*. Berlin, Heidelberg: Springer (Global Change — The IGBP Series). Available at: https://doi.org/10.1007/b137870.

Steffen, W. *et al.* (2015) 'The trajectory of the Anthropocene: The Great Acceleration', *The Anthropocene Review*, 2(1), pp. 81–98. Available at: https://doi.org/10.1177/2053019614564785.

Tuxill, J. (1999) 'Appreciating the benefits of plant biodiversity', *State of the World*, pp. 96–114.

UNDP (2022) *What is just transition? And why is it important?, UNDP Climate Promise*. Available at: https://climatepromise.undp.org/news-and-stories/what-just-transition-and-why-it-important (Accessed: 1 March 2024).

UNEP (2022) *State of Finance for Nature 2022, UNEP - UN Environment Programme*. Available at: http://www.unep.org/resources/state-finance-nature-2022 (Accessed: 1 March 2024).

United Nations Environment Programme (1992) 'Convention on biological diversity, June 1992'. Available at: https://wedocs.unep.org/20.500.11822/8340.

Westveer, J., Freeman, R. and McRae, L. (2022) *A Deep Dive into the Living Planet Index 2022, ResearchGate*. Available at: https://www.researchgate.net/publication/367412855_A_Deep_Dive_into_the_Living_Planet_Index_2022 (Accessed: 1 March 2024).

Winkler, K. *et al.* (2021) 'Global land use changes are four times greater than previously estimated', *Nature Communications*, 12(1), p. 2501. Available at: https://doi.org/10.1038/s41467-021-22702-2.

Yu, Y., Feng, K. and Hubacek, K. (2013) 'Tele-connecting local consumption to global land use', *Global Environmental Change*, 23(5), pp. 1178–1186. Available at: https://doi.org/10.1016/j.gloenvcha.2013.04.006.

Wageningen University & Research
Postbus 47
6700 AB Wageningen
T 0317 48 07 00
wur.nl

The mission of Wageningen University & Research is "To explore the potential of nature to improve the quality of life". Under the banner Wageningen University & Research, Wageningen University and the specialised research institutes of the Wageningen Research Foundation have joined forces in contributing to finding solutions to important questions in the domain of healthy food and living environment. With its roughly 30 branches, 7,600 employees (6,700 fte) and 13,100 students and over 150,000 participants to WUR's Life Long Learning, Wageningen University & Research is one of the leading organisations in its domain. The unique Wageningen approach lies in its integrated approach to issues and the collaboration between different disciplines.