

VITAL-PATHS-FOOD: New Transformative Change Pathways for Tackling Climate, Human Development, and Biodiversity Loss and Incorporating Plural Perspectives on Justice and the Value of Nature.

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Abstract

The IPBES Transformative Change Assessment (2025) gives a central role to equity, justice, and the value of nature in facilitating sustainable transformations, by acting as a powerful deep leverage point that aligns sustainability transformations with the values and worldviews different communities hold. Scenarios and modelling studies offer a tool for examining ways of acting on these leverage points through visualizing futures where climate and biodiversity goals are achieved in an equitable way, and through stakeholder participation in quantification studies examining the enablers and barriers to progressing along these pathways. This paper presents the VITAL-PATHS-FOOD - three novel pathways created within a “Story and Simulation” approach exploring how transformative change towards a nature- and human-positive future might be pursued within the global food-and-biomass system in line with competing perspectives on justice and the value of nature. Our approach bridges the Nature Futures Framework to explore the plural value of nature, and a novel framework – AJUST – to systematically incorporate competing preferences for distributive, procedural, and recognitional justice across three transformative change pathways. We detail how 5 key global food-and-biomass value chains’ elements differ across the pathways to reflect different justice and value-of-nature preferences.

We present narrative descriptions of these pathways and detail the methodology and rationale behind the project. We illustrate how variation in the way justice is conceived may lead to differences in the way that transformative change is pursued, due to differences in what policies are perceived as acceptable. We encourage engagement with the VITAL-PATHS-FOOD in new settings and different scales as a means of thinking through plural conceptions of justice with stakeholders.

Keywords:

“Scenarios” “Pathways” “Justice” “Biodiversity Loss” “Nature Futures Framework” “Food and biomass systems” “Values of Nature”

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Incorporating plural justice perspectives into transformative change scenarios.

Transformative change - “[global] reorganization [of] technological, economic and social factors” – has emerged as the most prominent framing for the action necessary for making progress on a range of interwoven global crises, including halting biodiversity loss (IPBES, 2019; 2025); the mitigation of harmful climate change (IPCC, 2022) and accomplishing the goals of the Sustainable Development Agenda (TWI2050, 2022). Such a comprehensive reorganization on a global scale is inherently political. It entails normative judgments about who should bear the costs and gain the benefits of the changes, whose interests take priority when choosing how resources will be allocated, and which principles guide these choices. Justice is therefore “unavoidable” when we discuss how to meet climate and biodiversity goals – it is a feature whether we explicitly talk about it or even recognize its presence (Shue, 1992). A central challenge in the study and implementation of justice within transformative change is that there is widespread disagreement over what justice demands (Oates, L & Verveld, L, 2024): individuals and groups within society have conflicting beliefs and preferences about what just processes and distributions of resources look like. Furthermore, differing conceptions of justice will also shape what is prioritized in transformation and the acceptability of trade-offs between which objectives to pursue. The importance of this cannot be understated, as it is increasingly recognized that conflicts over the perception of fairness of environmental policies are the key determinants of policy acceptability and success (Feola et al, 2019; Martin et al, 2020, Thaller et al, 2023; Bergquist et al., 2022; Paavola, 2004). Aligning environmental policy with different stakeholders’ perceptions of justice has therefore been recognized as a “deep leverage point” for making effective systems interventions and enabling transformation (IPBES 2025; Chan, 2020). However, to effectively utilize this leverage point, transformation research needs tools and methods for capturing competing conceptions of justice, to understand plural visions of desirable transformations, and to assess the impacts of pursuing alternative courses of action aligned with differing perceptions of fairness.

Scenarios and models have been identified as key tools for biodiversity science and policy (IPBES, 2016; Goudeseune et al, 2020; Lundquist et al, 2023). Scenarios – “[representations of] future trajectories of a system... plausible descriptions of how the future may unfold based on a set of assumptions about key drivers and their relationships” (IPBES, 2016) allow us to examine how transformative change might be pursued if the interests, values, and conceptions of justice of different groups of actors were prioritized (Zimm et al, 2024; Rosa et al, 2017). Incorporating a range of justice considerations, and diverse perspectives on these issues into scenario studies has been identified as key to developing the potential of scenarios to engage with deep leverage points to systems transformations, as they allow people to see how transformative change might be aligned with their deeply held values or worldviews (Balvanera et al., 2017; Bennett et al., 2016; Peterson et al., 2018; Chan et al., 2020; Obura et al., 2023; Zurek et al., 2021; Pascual et al., 2021). While IPBES has made laudable efforts to develop systematic methods for incorporating diverse perspectives on the value of nature into environmental scenarios with the Nature Future Framework (IPBES, 2016; Periera et al, 2020; Duran et al, 2023), there has not been a comparable effort to apply this approach to diverse perspectives on justice.

In this paper we introduce a new set of transformative change scenarios for the global food-and-biomass sectors – The **Value-explicit Transformative and equitable Pathways in Food-and-biomass Systems** (VITAL-PATHS-FOOD). The VITAL-PATHS-FOOD present three positive and potentially feasible visions of transformative change in global food-and-biomass systems towards nature- climate- and people-positive futures (Obura et al 2023), defined by the achievement of the objectives of multi-lateral frameworks such as the Kunming-Montreal Global Biodiversity Framework (KMGBF), the Paris Agreement and the Sustainable Development Goals. As such, the pathways are assumed to be broadly aligned with the target space described in van Vuuren et al (2022) for the Sustainable Development Pathways. Likewise, these three pathways are aligned with the NFF heuristics of plural value-of-nature perspectives, and specifically with the “New Narratives for Nature” scenario skeletons for positive human-nature futures developed by Duran et al. (IPBES, 2022; Duran et al, 2023). However, the Vital-Paths-Food are also differentiated according to influential¹ but competing accounts of distributive, procedural, and recognitional justice (Hanger-Kopp et al, 2024; Schlosberg et al, 2013; Taylor, 1995). The pathways therefore represented idealized/heuristic accounts of desirable transformative change that are *value-explicit* – consciously making explicit the values which they represent (Dooley et al, 2021; Zimm et al; 2023) while remaining *non-normative* – not taking a position on which justice or value-of-nature perspective ought to be preferred (Zimm et al, 2023; Minz-Woo et al, 2024; Hanger-Kopp et al, 2024).

Global food-and-biomass value chains were selected as the subject of the scenarios due to their central importance to Biodiversity, Climate, and Development policy. The key driver of biodiversity loss is habitat loss (IPBES, 2019), and particularly habitat loss in service of agricultural expansion (Corlett, 2020). Some two-fifths of the planet’s ice-free surface are now estimated to be under agricultural and livestock production (Machovina et al., 2015), or half of all “habitable land” (Ritchie & Roser, 2019) – effectively doubling since 1900. The effect has been what Rowlands describes as a “massive biomass reallocation program”, as “natural” grasslands and forests, including their animal inhabitants, have been replaced with a comparable slender range of crops and domesticates (Rowlands, 2021). The global food system and the associated land use changes (particularly deforestation) are also a central driver of global climate change (Boakes et al, 2024; IPCC 2019). Multiple pathways link food and biomass production to GHG emissions, including deforestation, burning of cover, drying of soils and draining of wetlands, and agricultural practices, including volume of fertilizer use and production, growth in livestock numbers and changes in livestock type, changes in energy use on farms, and energy used in the transportation and storage of agricultural produce, and agricultural waste. Any plausible strategy for halting biodiversity loss and limiting global climate change without negatively impacting human developmental objectives set out in the Sustainable Development Goals is therefore going to have to reckon with transformative change within this “food-and-biomass” system that governs most of the planet’s surface. The VITAL-PATHS-FOOD explores how transformation could occur within five broad but central aspects of these food-and-biomass supply chains

¹ We note that our study is informed by our positionality as researchers working within a particular scientific and ethical context; and this study limits its exploration of the impacts of different approaches to thinking about justice on transformative pathways to perspectives which have been influential *within the western philosophical tradition*. Further research should explore how other worldviews and distinctive ethical traditions might envision transformative processes.

(Agriculture; Forestry; Intermediate Processing & Transport; Protected Areas; Sustainable Consumption).

Methods

A “Story-and-Simulation” approach (Alcamo & Ribero, 2001) was used to design the VITAL-PATHs-Food (See Fig. 1). This method begins with an initial expert-led process that constructs the basis of the scenario storylines, drawing from literature review and original research and knowledge of the subject area. From an initial review process, we created a set of three draft narratives (Leclere et al, 2024). These initial drafts were then revised through an iterative process of qualitative feedback from expert stakeholders from within food-and-biomass systems and academics. The results of this feedback were then integrated into the three revised VITAL-Paths-Food narratives.

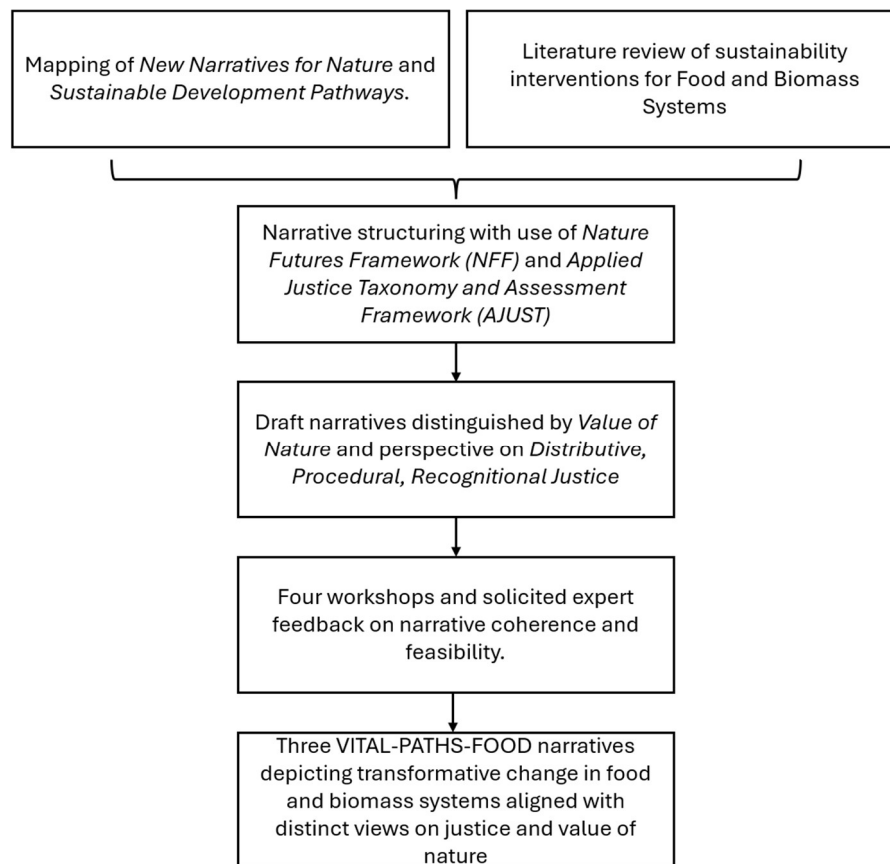


Figure 1 Schematic depiction of process of scenario development

Justice and Nature-Value Frameworks

To guide the incorporation of values-of-nature and justice, we utilized two tools in the scenario design processes for approaching these factors systematically and pluralistically. Firstly, the *Nature Futures Framework* (NFF) is a tool developed by IPBES for conceptualizing multiple contrasting accounts of the value of nature (IPBES, 2016; IPBES 2023; Periera et al, 2020; Kim et al, 2021; Duran et al, 2022) in order to explore competing visions of desirable states for anthropic and natural systems that appeal to stakeholders with different worldviews. “Nature for Society” (NfS) views hold that nature’s value is purely instrumental, i.e., nature is valued because it provides goods and ecosystem services which are instrumental for satisfying human ends, where

“living in harmony with nature” entails wise stewardship of natural resources to ensure that nature can continue to provide its instrumental benefits long into the future. “Nature for Nature” (NfN) views hold that nature has intrinsic value, conceptualized as an obligation to preserve certain parts of nature untouched even if/when there is no instrumental value to doing so (Duran et al, 2022). “Nature as Culture” (NaC) perspectives break down the intrinsic/instrumental dichotomy and see humanity as an inseparable part of nature. Valuing nature in this way is typically understood as entailing fostering close and mutually beneficial cultural relationships with nature. The NFF is a valuable framework for this study as it is a pluralistic framework, which while having a normative goal (achieving the KMBGF vision of “A World Living in Harmony with Nature”), has the operating assumption that each of the three ways of valuing nature are equally valid, non-mutually exclusive (and can be combined in various ways) and could each be the foundation of plausible pathways for achieving the goals of the KMGBF. The *Applied Justice Taxonomy and Assessment Framework* (AJUST) (Hanger-Kopp et al, n.d.) is a descriptive guideline for approaching justice in a non-normative way within scenario studies. AJUST is an example of a justice framework which provides consistent and explicit terminology for discussing justice in a transparent way, and detailing competing and influential theories of justice without presenting any view as the “correct” interpretation of justice. AJUST was therefore a valuable toolkit to be used for our scenario development exercise where the aim was to show how different ways of understanding the demands of justice would impact transformative change pathways. As with other justice frameworks, AJUST breaks down the concept of justice into conceptually distinct “forms”: distributive, procedural, and recognitional. However, within each of these “forms” there are multiple distinct answers to what justice entails; including competing “patterns” of distributive justice each representing a distinctive theory on when any given distribution of some important metric is just or not; but also what kinds of procedures and depth of recognitional specificity justice demands. The operationalization of each of these forms is discussed in turn.

Distributive Justice refers to the justice in how benefits and burdens are shared within a social context (Wenar, 2021; Rawls, 1985). There are, however, competing explanations for what a just distribution is. Taking a non-normative approach means adopting a pluralistic stance to this diversity – not trying to evaluate which perspective is “correct” or “just” but acknowledging that each view is minimally plausible and represents the justice preferences of some individuals, societies, or groups. We drew from the AJUST framework and identified five influential “patterns” of outcome distributions (Box 1).

Pattern of Distributive Justice	Description
Utilitarian	Distributions are just when they are the highest marginal utility solution; providing the greatest overall benefit per burden. Often the default assumption in cost-benefit analysis.
Egalitarian	Distributions are just when they promote equality of some key metric. Egalitarians seek policies that promote equality within their justice context.
Prioritarian	Distributions are just when they provide the greatest possible benefit to the currently worst-off. Similar to egalitarian but prevents “levelling down” to reach equality.
Sufficientarian	Distributions are just when all relevant parties have “enough” of some key metric. Inequalities are permissible if everyone has achieved a share above some pre-defined standard (e.g., the “poverty line”).
Limitarian	Distributions are just when they do not exceed a certain threshold. This theory sets an upper limit on how much of some metric any relevant party can have, and identifies injustice if any party has “more than enough”.

Box 1 Distinctive “Patterns” of Distributive Justice representing competing views about when distributions are just or unjust. drawn from the AJUST Framework (Hanger-kopp et al, n.d.)

Procedural justice refers to justness in the design and operation of decision-making and distributive- processes. As with distributive justice, there are substantive disagreements over what features a process requires to be “just”, such as who needs to be involved in a decision-making process, and at what degree of participation, and when (if ever) governing institutions can utilize coercive authority. Levels of citizen participation are often conceived of on a spectrum of low- or non- participation, top-down control, or active manipulation, to increasing levels of decision-making authority and citizen involvement (E.g., Arnstien, 2019; Lawrence, 2008; Epstein, 2017). While the “all-affected principle” is increasingly championed as the gold-standard of procedural justice in environmental decision-making, it has also been found that greater procedural inclusion does not always result in greater decision-making legitimacy (Fudge, 2018), indicating, for at least some stakeholders, that greater inclusion is not the primary virtue they expect from environmental decision-making. Taking a non-normative approach entails viewing procedures with low levels of citizen participation as not *inherently* unjust but reflecting a different, less demanding, view of what procedural justice demands of decision-making authorities.

Recognitional justice refers to the appropriate apportionment of dignity and recognition between individuals and groups within a society (Honneth, 2008). We conceptualized this in our pathways as how institutions seek to reflect and consider the culture, values, and situations of affected parties (Whyte, 2011) and alter their behavior to account for that specificity. As justice refers to “enforceable obligations” (Miller, 2007) we operationalize recognitional justice as a spectrum (wide to narrow) of views over when institutions/governments/decision-makers are obligated to

recognize the specific/distinct needs of groups within society (Taylor, 1994).² A pathway with a narrow account might focus on ensuring a liberal conception of “equality-before-the-law” that does not recognize differences between parties, whereas a wide account might have provisions within governing institutions or laws which give explicit special consideration or affirmative action to presently sub-altern groups or culture. As with procedural justice, this is not a spectrum of justice-to-injustice, but rather reflects distinctive accounts of what justice requires.

Mapping existing value-explicit pathways

In order to identify common narrative elements and build up initial draft versions of the Vital-Paths-Food we drew on two existing sets of scenario narratives: The *New Narratives for Nature (NNNs)* which provide six “scenario-skeletons” aligned with NFF values-of-nature (Durán et al., 2023; Pereira et al., 2020), and the *Sustainable Development Pathways (SDPs)* (Kriegler et al., 2022; Soergel et al., 2024; Downbrowsky et al., 2025) which offer three scenario pathways for achieving the sustainable development goals; distinguished according to contrasting worldviews and value systems. Both scenario-sets describe alternative visions of positive futures where multilateral agreements on biodiversity, climate, and human development objectives are achieved, and do so with a global scale and mid-century timespan. They therefore align with the objectives of the Vital-Paths-Food.

In order to combine the existing narratives, two mapping exercises were conducted to evaluate alignment between individual scenarios within the *NNN* and *SDP* sets. The five SDPs were first aligned to Nature Futures Framework accounts of plural valuations of nature. Mapping exercises are a commonplace use of the NFF though little methodological guidance exists on how to plot positions onto the framework (Lunquist et al, 2023; Peterson & Penrose; n.d.; Okayasu, et al; 2025). We utilized the description of the characteristics of each cardinal point of the NFF provided by Kim et al (2021) and Duran et al’s (2023) depiction of the relative space of the NFF as three “nature value gradients” of “management intensity”, “utilitarian intensity”, and “importance of culture” (capturing three key debates in the transformative change for nature debate “land-sharing vs land-sparing”, “half earth vs whole earth” and “green growth vs post-growth”) as the basis of the mapping of the SDPs to the NNN’s based on thematic analysis of the SDPs.

Additionally, the SDPs were mapped to the axes of distributive, procedural, and recognitional justice. As with the axis of nature-values used by Duran et al (2023), these justice-axis reflect simply heuristic proxies for the three forms of justice under consideration and are not axis of “just-to-unjust” but rather proxies for competing perspectives on what each form of justice substantively demands. Distributive justice is expressed as the relative ethical importance of inequality, with the views at the top being highly egalitarian, whereas the views at the bottom

² Charles Taylor describes two trends within the “politics of recognition” and the conceptualizations of what is needed to confer dignity in recognition. A “universalist” tradition which emphasizes the equal dignity of all citizens, expressed in the equalization of rights and entitlements and a strict aversion to legally constituted “first and second” classes of citizenship – typified in the works of Rousseau. Then a “differentialist” tradition which has in various ways tried to highlight the moral inadequacy of “difference blindness”, and has tried to identify occasions where failing to recognize differences between individuals results in inequality in dignity even when all parties are formally equal in the eyes of the state. These two traditions can be understood as representing two competing accounts of what recognitional justice requires. See: Taylor, C., (1994) *The Politics of Difference*. In Gutman, A., (eds.) *Multiculturalism: Examining the Politics of Recognition*. Princeton University Press.

represent views that can tolerate inequality. Procedural justice is conceptualized as an axis of highly plural to expert-led decision-making process. Recognitional justice is conceptualized as an axis of “wide” to “narrow” expectations of what kinds of specificities that states are required to recognize, roughly mapping to the Universalist and Differentialist traditions identified by Taylor (1994). These results are presented in the table below.

Form of Justice, NNN axis	Operationalization	1	2	3	4
Distributive Justice	Explicit focus on inequality reduction (1) to No explicit focus on inequality reduction (4)	Resilient Communities.	Managing the Global Commons.	Global Social and Market Transition	Economy-driven innovation
Procedural Justice	Highly participatory decision-making processes (1) to Expert-led low participation processes (4)	Resilient Communities	Global Social and Market Transition	Economy driven innovation	Managing Global Commons
Recognition al Justice	Wide differentialist account of equality (1) to narrow universalist account of equality. (4)	Resilient Communities	Global Social and Market Transition	Managing Global Commons	Economy Driven Innovation
Importance of Culture	Low importance in Nature for Nature & Nature for Society (1) to high importance in Nature as Culture (4)	Economy-driven innovation	Global Social and Market Transition	Managing the global Commons	Resilient Communities
Utilitarian Intensity	Low intensity in Nature for Nature & Nature as Culture (1) to high intensity in Nature for Society (4)	Resilient communities	Managing the global commons	Global Social and Market Transition	Economy driven innovation
Management Intensity	Low intensity in Nature for Nature (1) to high intensity in Nature for Society and Nature as Culture (4)	Managing the global commons	Resilient Communities	Global Social and Market Transition	Economy driven innovation

Source: Authors' elaboration

The mapping exercise revealed that the “Resilient Communities” (RC) pathway scored low across all three justice gradients, demonstrating a focus on a high plurality of voices in governance,

through large-scale popular engagement and citizen assemblies; particularly marginalized and vulnerable people; and using this popular governance to facilitate sustainable economic degrowth supported by large-scale resource redistributions. “Economy driven innovation” (EI) was most frequently positioned opposite RC on the justice gradients – with a highly liberal account of social justice focused on equality before the law and the free functioning of markets with little government interference. Across all axes, both of justice and of human-nature value, “Managing the Global Commons” (MC) and “Global Social Market Transition” (GS) frequently occupied the middle of each gradient, each with a comparatively balanced position on the centrality of distributive inequality reduction and the need to account for a plurality of interests. The more distinctive of the two was MC, which had a strongly expert lead/managerial account of procedural justice, where governments were increasingly empowered to make executive decisions in relation to achieving the aims of the SDGs with lower input from civil society and private sector actors.

In the “nature value gradients” from Duran et al, MC shared the most similarities with RC. RC aligned with the Dynamic Natures (NN-NC) pathway, as it focused on post-growth, where nature is viewed with values such as stewardship and the importance of non-use values of nature through sustainable production and consumption with high-levels of self-sufficiency and low material use, with a preference towards multifunctional landscapes and emphasis on localization and preference for community decision making that would support traditional and local cultural valuations of nature. MC, however, mapped to NN-NS but with a focus on maintaining ecosystems for the benefit of human need through a global institutional and economic convergence focusing on wellbeing, social work & access to services. EI was found to closely align with the Sharing through Sparing (NN-NS) pathway due to the narrative being based on a liberal economic and social worldview where societies view green-growth as the key to sustainable development; and see (protecting) nature as instrumentally valuable in making optimal individual social welfare calculations. GS leans more towards the green growth end than the post-growth end, but is less strictly instrumental in its valuation of nature than the EI pathway, with a focus on efficiency, material recycling use rate, and technology, with a preference for precision farming and intensification, and a global perspective on food value chains but still allowing for more local food systems than the EI pathway.

This mapping allowed us to identify the outlines of three draft pathways which could serve as the “skeletons” (Duran et al, 2023) for the VITAL-Paths-food, around which full scenarios could be built based on the plan for feedback and revision outlined in Figure 1. Owing to the similarities between MC and GS, these were merged into a single pathway focused on global, top-down co-ordination and expert-led governance, aimed at managing the transition towards a “half-earth” “Arcology/Sharing through Sparing” scenario while mitigating the impacts of doing so on poverty elimination and developmental outcomes. EI was linked to Sharing through Sparing as well but aimed to make the land-use efficiency gains needed to find additional space for nature through green-growth technological innovation and using nature-market forces to determine optimal placements of productive/non-productive land. RC was linked to “Dynamic Nature” as a land-sharing pathway enabled by localized governance, horizontalization of value chains, and valorization of traditional and low-impact production methods. Table 2 gives an overview of these draft pathways.

Vital Path Food Scenario	New Narrative for Nature Mapping (Value-of-Nature Perspective)	Sustainable Development Pathway mapping	AJUST Framework Justice Perspective (Distributive & Procedural & Recognitional)	Two-line description.
International Market Innovation.	Sharing through Sparing.	Economy Driven Innovation	Utilitarian.	Green-growth oriented pathway which spares land for nature though market-led efficiency gains in the productive and intermediate sectors.
	Balancing Nature for Nature & Nature for Society		Medium emphasis in plural decision making.	
			Balanced Universalist/Particularist.	
Global Ecological Orchestration.	Arcology/Sparing through Sharing.	Managing the Global Commons	Prioritarian.	International cooperation and expert led governance for economic coordination aimed at ending poverty while sparing land for nature.
	Nature for Nature		Highly expert-led decision making.	
			Universalist – equal rights for all low distinction.	
Local Commons Stewardship.	Dynamic Natures. Balancing Nature for Nature and Nature as Culture.	Resilient Communities	Egalitarian (locally) & Limitarian (globally).	Devolved egalitarian polities seeking locally specific and culturally aligned sustainability transitions. Sharing land with nature by transitioning to organic & regenerative agriculture.
			Highly pluralistic, communities have strong levels of decision-making authority.	
			Wide particularist recognition of distinct groups.	

Table 1 VITAL-PATHS-FOOD Mappings to the SDPs, NNN/NFF, three views of Justice, and short scenario depictions.

Conceptual review of sustainability interventions

To deepen the content of the scenario narratives, we undertook a review of sustainability interventions (Dorninger et al, 2020). There is significant variation in types of interventions and numerous typologies for classifying and distinguishing them (Harrison, 1998; Wurzel et al, 2019; Börner & Vosti, 2012), and – we take it that – our views on justice and the appropriate way to treat nature will influence which interventions we see as legitimate or aligned with our values.

A commonplace differentiation is between “command-and-control” interventions – top down regulatory “sticks” for coercing behavioral changes – and “new” environmental policy interventions – typically non-coercive voluntary or incentive “carrot” based measures (Wurzel et

al, 2019; Jordan et al, 2005; Harrison, 1998). The differentiation of interventions on this coercive-voluntary axis aids in identifying which interventions are used in each scenario, as different perspectives on both procedural and recognitional justice disagree on what the legitimate use of the state's coercive authority is and therefore what kinds of interventions may be used to advance transformative change. Likewise, normative disagreements within distributive justice provide justifications for when goods must be redistributed. We develop a conceptual model which distinguishes four kinds of interventions targeting different segments of food-and-biomass value chains.

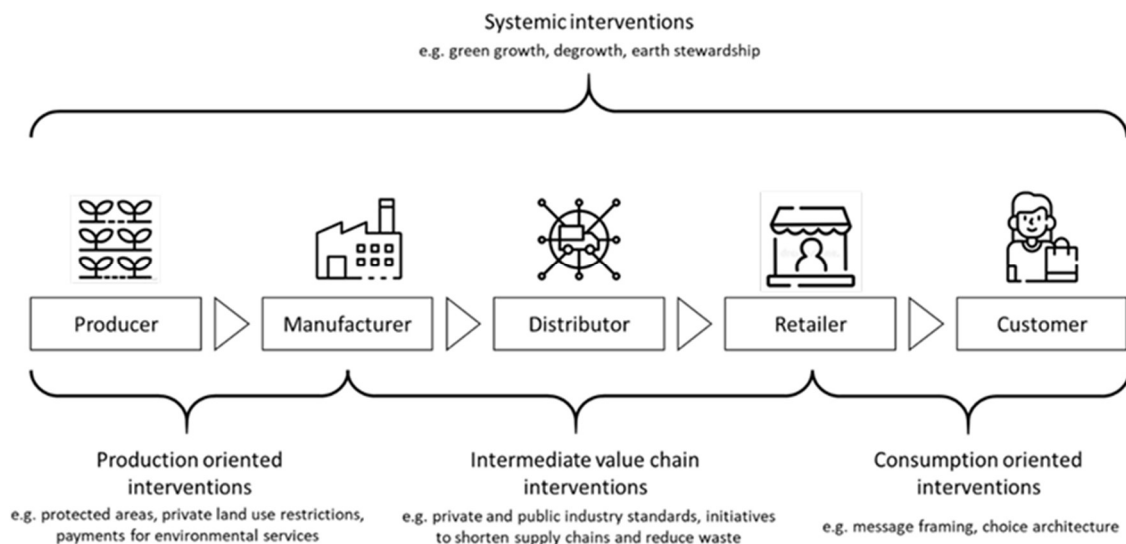


Figure 2 Conceptual model of sustainability interventions at different locations within food & biomass value chains. Source: Leclerc et al, 2024

Production-oriented interventions aim to influence primary food-and-biomass *production*. (agriculture & forestry). Governments can utilize regulatory interventions backed with coercion (e.g., fines, asset confiscations, imprisonment) to intervene in primary productive sectors (Lambin et al, 2014; Robinson et al, 2010; Börner et al., 2020) or impose regulations on the use of fertilizers, land-zoning or use-restrictions (Oliviera & Meyfroidt, 2021), environmental taxes to disincentivize environmentally harmful uses of land (Fendrich et al, 2022), or designate and enforce the protection of conservation areas (Maxwell et al, 2020). Incentive-based measures include payments-for-ecosystem-services (P.E.S), which provide monetary incentives to adopt practices that promote ecosystem services (Barton et al., 2017). “Biodiversity offsetting” schemes require habitat loss from new development to be “offset” by greater or equal habitat creation elsewhere, with trading schemes allowing some producers to benefit from restoring land.

Intermediate value-chain interventions focus on all aspects of the value-chain which occur between production and consumption; typically processing & manufacturing of primary goods, distribution of those goods; and wholesale & retailing. These aspects of the value-chain can play a key role in reducing biodiversity and climate impacts, through establishing environmental product standards, leveraging market access, incentivizing or disincentivizing certain product types, through influencing spatial relations of production and consumption (e.g., by shortening or lengthening supply chains), and through interventions for influencing supply-chain food loss

and waste. How global trade relations are structured is also a central question of global justice (Kapstien, 1999; Garcia, 2003; Emmanuel, A., 1972), and different perspectives on what a just distribution of global goods is will influence our favorability to different trade policies. Currently private companies are the majority actors in the intermediate value chains and can influence sustainability through collective aspirations, company pledges, company codes of conduct, and setting sectoral standards (Lambin et al, 2018). With the liberalization of global trade in the 80s, governments have reduced their influence in supply chain management. However, the past two decades have seen a recentering of the state in regulating supply chains, and a transformative scenario could further reinforce that relationship. Governments can influence supply chains through setting minimum standards, taxing products to disincentivize them, industry regulation and nationalization, tariffs, and industry incentivization's (Nezakati et al., 2016; Vermeulen & Kok, 2012), or through the development of state operated enterprises.

Consumption-oriented interventions act at the end of value-chains, where goods are consumed by customers including both private corporations and individuals. This can be through shifting dietary habits (e.g., towards plant-forward diets) (Scarborough et al, 2014), (reducing) consumption quantities, and reducing consumption waste. Governments can shift consumption with either coercive (stick) or incentive (carrot) based measures. Our perspectives on the legitimacy of different consumption-oriented interventions can shift depending on our justice views (Kukowski et al, 2023; Wang, 2017) and perspectives on when its permissible for governments to coercively shape consumption outcomes, utilize “nudges”, or act paternalistically (Sustien, 2015a; Waldron, 2014; Lucas, 2024). Other interventions include awareness-raising and education programs, or technological solutions aimed at waste reduction (e.g., refrigeration and packaging (Schanes et al, 2018)).

Systemic-interventions take actions which reshape and alter the value-chain in totality, rather than targeting a specific group of actors or sectors, they seek to alter the operating logic of the systems they are a part of. IPBES (2022) has argued that systemic change across the whole of society is required to halt biodiversity loss, and identifies three approaches aligned with different nodes of the NFF and views on justice. “Green-growth” seeks to utilize market-forces ability to produce innovation and find cost-effective solutions as a driver of change, by subtly altering incentive structures of markets to decouple economic growth from producing negative environmental externalities. “Degrowth” sees this decoupling as difficult or impossible on the required timescales and instead argues that states/economies should manage a reduction of overall activity to minimize the impact on climate and nature and regulate production and consumption so that this economic contraction does not compromise the ability of all to escape poverty. “Earth-stewardship” takes an agnostic position on growth but instead argues for a “reconnection” of communities with their natural surroundings, through economic forms which emphasize local sovereignty, community ownership, and solidaristic relationships between community members.

Revision and Feedback of the Draft Narratives

From the mapping of existing narratives according to justice & value of nature perspectives, and the review of potential interventions to act as storyline elements, three draft narratives (in the

form of short narrative descriptions and tables highlighting key narrative elements across the scenario themes) were created (Leclerc et al, 2024³; Woodhouse et al, 2025).

International Market Innovation – a global green-growth pathway where private enterprises increasingly make productive investments into sustainable production techniques and are supported by government-regulated markets for ecosystem services to use the profit incentive to find high- marginal utility solutions for managing biodiversity positive land use changes.

Global Sustainability Orchestration – a globally governed pathway with a focus on international expert led-cross sectoral planning to make effective use of resources while expanding protected areas and without compromising poverty elimination goals.

Local Commons Stewardship – a pathway with substantial political devolution towards local communities, who seek to rebuild strong communal and culturally appropriate ways of managing their local bioregions; often holding resources in common and creating moral norms for protecting nature.

To continue with the iterative development of the VITAL-Paths-Food, we sought feedback on draft versions of the narratives through a combination of two in-person and two online workshops, plus interviews and detailed written exchanges with selected individual experts from the food and biomass science-policy interface and global biodiversity and scenario and modelling experts. In total, we received tailored feedback from 50+ academic, industry, civil-society, and public sector experts on food-and-biomass value chains or scenarios and modelling. Details of this process can be found in the publicly available deliverables of the Horizon Europe RAINFOREST Project (Woodhouse et al, 2025). In the feedback sessions, we sought feedback chiefly on three factors:

- Stakeholder and expert perceptions of the alignment of the interventions included in each narrative with the depicted justice and nature values.
- Perspectives on whether the draft narratives were sufficiently distinct from each other, as to represent clearly distinguishable value heuristics.
- Expert assessments of the perceived feasibility of each pathway, and enablers and barriers for each pathway, including which food-and-biomass stakeholders were likely to align with each pathway, and what actions they might take to influence the current food and biomass system towards this scenario.

The key findings of the feedback sessions were that, on the whole, the initial draft narratives were understood as internally coherent and well aligned with the nature-values and justice preferences which were intended to be depicted. Feedback predominantly requested further differentiation between the two globally governed pathways IMI and GMO on the role that multi-national cooperations would play, and clarification on the enforcement mechanisms within LCS for aligning communities who do not share their transformative vision or seek to block

³ Note that draft pathways presented in this report have different names. These have been standardized with the final names for clarity purposes in this paper.

sustainability interventions. This feedback was incorporated into the revisions of the narratives into their final versions presented in the next section.

VITAL-Paths-Food Narratives

The following sections detail the three Vital-Paths-Food narratives. Key elements of these narratives are presented as a table in Appendix 1.

International Market Innovation

Overview

This pathway represents a green-growth transition scenario in accordance with a *utilitarian* account of distributive justice, a moderate emphasis on participatory decision-making, and a narrow/universalist account of recognitional justice. In combination with an instrumentalist account of the value-of-nature, this pathway is focused on protecting nature by fully valuing it within a globalized market economy, where the private sector plays a dominant role in driving the development of new technologies and products which aim to decouple economic growth from adverse effects on climate and biodiversity (Hickel & Kallis, 2019; Briggie, 2024; Pielke, 2010; Stoknes & Rockström, 2018).

Agriculture

Agriculture in this pathway prioritizes land-sparing (Phalan et al., 2011) and pollution reduction through efficient production intensification. The state's role is primarily to create a regulatory environment that incentivizes market actors to shift towards high-yield, low-impact production, for instance through instituting biodiversity-offsetting and payments-for-ecosystem services schemes to ensure that environmental externalities are priced into market- decision making. This creates financial incentives to raise yields as the cost of land conversion rises. Agribusinesses increasingly adopt precision-farming technologies to reduce fertilizer, pesticide, and water use (Chen et al., 2022), which favor larger farms and enable higher per-hectare yield (Balagoutis et al, 2017; Clapp et al, 2020). This saves space for degraded areas to be restored. Livestock production too becomes increasingly intensive as producers seek technological innovation in the sector to produce more with less, mitigate harmful externalities, and continue to provide for a wealthier world with a demand for meat (Havlik et al, 2014). In agricultural regions, large-scale highly productive monocultures dominate, allowing restoration of the least productive agricultural lands for nature. Ecosystem-service pricing incentivizes restoration of some marginal lands, but the low pollination dependence of staple crops reduces the need for extensive on-farm restoration of semi-natural elements. The global nutrient-loss and pesticide reduction target is achieved on a global, cross-border basis via credit-based trading programs allowing fertilizer budgets to be “spent” where they will have the greatest social utility, and stimulating investment into alternatives – including precision agriculture technologies such as targeted spray systems.

Forestry

Forestry also follows a space-saving model emphasizing high-yield plantations and optimized ecosystem service provision in productive areas, with the restoration of natural and protected forests elsewhere. Forest placement is optimized through a payments-for-ecosystem-services (P.E.S) market that allows forests to be valued for their co-benefits (e.g. water regulation), allowing the market to determine high marginal utility locations for new forests (Simpson et al.,

2011). Ecosystem connectivity is directly planned for (Jongman, 2002), but nevertheless, landscape specialization often yields connectivity. Globally, this strategy favors an expansion of forests in regions with optimal growing conditions with low costs to acquiring land, particularly tropical roundwood plantations and high-latitude reforestation. Fast-growing plantations provide an increasing share of wood biomass harvest due to their profitability and climate mitigation potential through harvested wood products and bioenergy with carbon capture and storage, which is central to this pathway's slower emissions reductions. Non-native species are tolerated in plantations where beneficial for productivity, reflecting an instrumental and utilitarian rather than intrinsic valuation of nature. P.E.S schemes support afforestation on marginal or abandoned farmland for nutrient attenuation and water management. The state plays a minimal role in safeguarding against market imperatives towards the conversion of ecologically valuable non-forest habitats, but overall facilitates a continued liberalization of the sector (Mi et al, 2024; Sohail et al; 2024).

Trade & Intermediate Value Chains

States see their role as working with market-actors to set sustainability regulations for nature markets, but are committed to continued globalization, removal of trade-barriers, and expansion of free-market principles. This is understood as a demand of justice but also a necessary condition for green growth by accelerating the diffusion of green technologies, creating competition to improve environmental performance, enhancing resource efficiency, and diffusing environmental standards and best practices (Murshed, 2020; Hu et al, 2024; Wang, 2018). While states cooperate in some international standard settings, competition for increasingly eco-conscious consumers also creates an upward pressure for corporations to adopt and promote their own voluntary standards. Trade remains globally interconnected, allowing primary production to occur in market-optimal locations. Reducing pre-market food losses becomes essential to sustain biodiversity goals while allowing for higher overall consumption than in the other pathways, and as costs of productive land rise, industry invests more into processing innovations to reduce spoilage and waste enhanced computational logistics and infrastructure investment.

Protected Areas

Intensified agriculture and forestry significantly reduce opportunity costs for new protected areas. Governments aim to further minimize the global economic burdens of setting land aside for conservation by allowing market mechanisms (P.E.S and biodiversity offsetting) to determine the placement of protected areas on land with the highest ecosystem service value and lowest commercial conflict. The KMGBF 30-by-30 target is therefore achieved cumulatively, with some countries in cost-effective conservation regions taking a share greater than 30%, allowing the most efficient use of public funds (Youatt, 2015). In high-land value regions, protected areas are established on low-productivity or high-ecosystem-service lands. Some global coordination tempers the market and ensures that irreplaceable ecosystems like the Amazon are safeguarded to prevent tipping points. Following the IUCN framework (2008), the dominant categories are “Managed Resource Protected Areas” and OECMs, complemented by targeted “Habitat/Species Management Areas.” Indigenous Peoples and Local Communities (IPLC) are recognized as cost-effective stewards, compensated for ecosystem service provision via formalized tenure where

appropriate (Naughton & Sanderson, 1995). Compensation follows market-based “willingness-to-accept” pricing (Armstrong, 2024).

Ecosystem connectivity is not planned top-down but emerges incidentally rather than by design as a feature of the market-led approach and by incorporating connectivity indices into biodiversity offsetting frameworks (Naumann et al., 2011; Wood, 2020). Protected areas often remain multiple-use landscapes, supplying ecosystem services and economic benefits through tourism, genetic resources, and credit markets.

Sustainable Consumption

Consumption remains comparatively high and globally uneven as market-actors have comparatively low incentives to reduce over-consumption; instead, the impacts of consumption on climate and biodiversity are predominantly reduced through production efficiency gains and transitions onto more sustainable alternative products, in particular novel products combining lower environmental impacts with high value added and limited change in lifestyle, such as novel plant-based alternatives. This is driven by both demand and supply side factors - consumer demand for sustainable products but also suppliers transitioning the products they offer to sustainable alternatives as a form of risk mitigation against ecological collapse (IPBES, 2026). Consumers’ preferences for sustainable goods pressure companies to meet higher standards, while firms actively shape these preferences through R&D and marketing (White et al, 2019).

Governments employ minimal coercion to shift consumption, limited to nudges, labelling, and moderate externality pricing. Product substitution is seen as preferable to consumption reductions as it enables sustainability without major lifestyle changes. Corporate responsibility initiatives and circular economy principles such as product-as-service models internalize packaging waste costs and incentivize recyclable design, but post-sale food waste remains comparatively high as companies have the least leverage here. Technological solutions predominate over intense shifts in consumer behavior, including food preservation advances, distribution systems, and retail logistics (Agya, 2025).

Global Environmental Orchestration

Overview

This pathway represents a future with a prioritarian account of distributive justice, highly expert-led decision making, and an intermediary view on relational justice, whilst having an intrinsic valuation of nature. To manage the dual challenges of halting biodiversity loss while also redistributing economic benefits to the globally worst off, global/international organizations and institutions are given increasing political authority to make policy and guide the transition. It is focused on an expert-coordinated space-saving concept, creating large and interconnected areas of highly protected areas and relocating production to regions that can best bear the impact, while using top-down economic planning to temper market-forces and ensure that this does not impede communities’ escape from poverty.

Agriculture

Expanding large, interconnected protected areas places pressure on cultivated lands (Mehrabi et al., 2018), requiring both yield intensification and resource redistribution to meet poverty elimination goals (Balmford et al., 2015). Global-governance institutions coordinate agricultural

production, trade, and distribution to ensure food security (Schmidt-Traub et al., 2019). Production intensification combines precision-farming and conservation agriculture (Garbach et al., 2016), guided by a “consider all options” ethos (Royal Society, 2009). Risks of price rises due to increased competition with natural land are mitigated by a global effort to provide compensation to communities who give up land for conservation (Fischer et al., 2018).

Technological investment is focused on sustainable mechanization, where states in the Global North transfer technology and finance to bridge mechanization gaps in the Global South, enabling productivity gains while aiming to avoid a Lewis-trap, and displaced rural labor is redirected toward ecological restoration (Vittis et al, 2022; Dorin et al., 2013; Sims & Kienzle, 2017). Farm structures favor medium-to-large units enabling mechanization and economies of scale but states take policy action to avoid monopolization of production by large agri-businesses and ensure that production and ownership structures remain aligned with poverty alleviation and sustainable development. Harmful subsidies are eliminated in their place states cooperate on cross-border incentive regimes to prioritize plant-based, nutrient-rich staples—legumes, grains, nuts, and vegetables (Willet et al., 2019). The KMGBF 50% nutrient loss and pesticide reduction targets are met through coordinated global fertilizer budgeting and redistribution, channeling use to regions with ecological capacity to absorb it, and also to regions where its use would provide the greatest social benefit.

Forestry

Forestry adopts intensive, space-saving, production outside protected areas to supply construction materials, while also using productive quasi-natural forests to meet ecosystem connectivity goals (Zannotti & Knowles, 2020; Potapov, 2017). Timber demand continues to grow, and engineered wood technologies are promoted to minimize material use while maximizing carbon storage in new buildings. States play a greater role in forestry, and national agencies are able to avoid some commercial imperatives to site new forests strategically for biodiversity co-benefits, to focus on natural species, allow foresters to follow longer rotations emphasizing sustainability over profit maximization, and to promote connectivity (Keeley et al., 2018; Watson et al., 2018).

Trade & Intermediate Value Chains

Global trade remains extensive and long supply chains persist in enabling production to occur in ecologically optimal regions. However, new global regulatory institutions are empowered to mediate market forces to ensure that global trade is aligned with prioritarian distributive objectives - including through creating new environmental Pigouvian taxes (Gsottbauer et al, 2025), conditional debt-forgiveness (IIED 2025), and development financing programs for ensuring North-South capital flows needed to ensure that biodiversity and climate goals do not present an additional barrier to development (Pogge, 2001; Brock, 2008). To control against perverse incentives from stranded assets, states increasingly use their power to bring environmentally harmful industries into public ownership, allowing them to be wound down whilst ensuring a just distribution of benefits and burdens (Green & Robeyns, 2022). Price-controls on staple goods and environmental technologies reduce profits for intermediate value-chain actors but protect the worst from food price rises. Global infrastructure funds and weakened intellectual property regimes facilitate technology transfers, including infrastructure

improvements in the Global South needed to minimize post-harvest food losses (IISD, 2018). Financing mechanisms such as global conservation funds and debt-for-nature swaps support compensation for protected area expansion. International governance agreements aim to standardize sustainability regulations across borders, facilitate technology transfer and build governance capacities, and enable cooperation (Qi, 2024).

Protected Areas

Intrinsic value ethics underpin a global commitment to large, interconnected, and strictly protected natural areas. The KMGBF 30% target is achieved through expansive wilderness-style reserves in ecologically optimal locations over cost efficiency (Jung et al, 2020a; Kopnina et al, 2020; Wilson, 2016; Keeley et al., 2018) and governed by strong international enforcement (IUCN, 2008). Planning is top- down and expert-led, based on objective scientific assessment of optimum placements to halt biodiversity loss, at the expense of more inclusive participatory options for planning and management (Brockington 2004). Biodiversity offsetting is rejected as incompatible with recognizing nature's intrinsic value (Karlsson & Björnberg, 2021). National authorities explicitly aim for connectivity between existing and new reserves to sustain functional ecosystem processes (Fitzsimons et al., 2013; Worboys & Lockwood, 2010). ES provision is also sought but is a secondary consideration to meeting ecological needs. Governments consider rights-of-nature approaches to planning, and see meeting their obligations to restoring nature as part-and-parcel of their prioritarian approach to justice.

Governments are aware that such a strategy presents distributive justice challenges, as high-biodiversity regions overlap with poverty zones and therefore risks levelling additional burdens on the globally worst-off. This is handled through robust compensation regimes, agreed at an international level and financed through reparative payments from the Global North (Kopnina et al., 2018). Global financing mechanisms ensure compensation for land lost and opportunity costs based on moralized anti-poverty baselines (Armstrong, 2024) to ensure that expansion of protected areas does not jeopardize escape from poverty.

Sustainable Consumption

Consumption patterns are restructured to reduce overconsumption in the Global North to reduce the offshore footprint and thereby mitigate land-use conflicts in the tropics where development/conservation conflicts are most pronounced (Lenzi *et al*, 2023). Redistribution of resources, capital, and technology is coordinated via international agreements and a push towards greater global material equality is understood to be a conservation measure (Holland et al, 2009). Governments utilize regulatory authority to shape global consumption patterns through diets consistent with ecological limits (e.g., EAT-Lancet framework). Governments are willing to utilize “push” strategies to enforce consumption shifts in line with expert recommendations, including taxes on luxury goods, emissions, and meat consumption, removal of harmful subsidies, and mandatory waste reduction targets within industrial and agricultural sectors, backed by a willingness and architecture to prosecute offenders.

Local Cooperation & Stewardship

Overview

This pathway sees a just transition as involving a greater devolution of political power towards the local and regional level, allowing communities to make locally specific interventions in line with their values and with increasingly egalitarian relations among themselves. This aligns with a “post- or de-growth” economic model (Fioramonti, 2017a; Schneider, Kallis & Martinez-Alier, 2010), where growth and accumulation are deprioritized in favor of a needs-based economy. This pathway takes a “land-sharing” approach, switching to low-impact forms of production but bringing more land into production. Biodiversity is embedded throughout managed landscapes rather than confined to exclusionary reserves. Communities often govern their resources as commons (Ostrom, 1990; Federici, 2018)) and produce much of what they need close to home and in cultural attenuated ways.

Agriculture

Agriculture transitions toward a “land-sharing” approach with extensive, low-input, and agro-ecological systems rooted in traditional and regionally specific practices (Agnoletti & Santoro, 2022; Koohafkan & Altieri, 2016). While sustainable intensification and precision agriculture exist, especially where space is at a premium (Rodriguez et al., 2024) small, labor-intensive farms within mosaic landscapes of cropland, forests, and more natural lands is the preference. Ecosystem restoration occurs largely on-farm through integrated mosaics of semi-natural habitat that secure pollination, water regulation, and soil fertility upon which restorative agriculture depends. Rural communities resist and revert large-scale mechanization and “farms-without-farmers” dynamic that displaces labour and erodes agrarian traditions (Bernstein, 2004; Peters, 2013; Li, 2010; Senthold & Asche, 2019). Farms frequently use climate-resilient heritage crops (Doggalli & Srivastava, 2024) with cultural co-benefits and “appropriate technologies” (Hazeltine, 2004). Input-use declines through both lower output and careful nutrient and pesticide management, facilitated by reduced consumption and a needs-based economy and more even global consumption. Livestock remain integral for nutrient cycling and cultural diets, though consumption shifts toward “less-but-better”, high-quality, ethically produced meat produced close to home and declining overall, especially in regions where animal-based products are above what is needed. Nutrient loss declines due to organic and low-till methods emphasizing high circularity (Kirchmann & Bergström, 2001). Artificial fertilizer and pesticide use sees steep reductions, with communities committing to comparatively equal shares of a global budget, allowing all to benefit from its use, (Conner, 2008).

Forestry

Forestry evolves into a mid- to low-impact, community-managed system emphasizing culturally specific relational uses (Himes & Dues, 2024; Mulyoutami et al, 2023; Hakim et al, 2023). Forest landscapes form extensive mosaics interwoven with farms and restored semi-natural land. Management prioritizes native species, long rotations, and mixed-objective forestry that supports biodiversity and ecosystem services while sustaining cultural and aesthetic values (Erickson et al., 2002). Local communities use forests to meet diverse needs from timber to food production and prefer managed semi-natural forests over a dichotomy of intensely managed/strongly protected landscapes. Demand reduction and recycling limit pressures for

expansion, and exotic plantations are gradually replaced by near-natural woodlands. Forests contribute to ecosystem service provision for agriculture, particularly pollination and water regulation. Traditional silvicultural practices re-emerge, creating multifunctional forests valued for recreation, cultural heritage, and biodiversity.

Trade & Intermediate Value Chains

Communities seek to produce closer to home and consequently supply chains shorten, reducing food miles and post-harvest losses while promoting direct producer–consumer relationships through cooperatives and farmers’ markets (Edelman, 2014; Davies, 2019). Local economies prioritize food hubs and farm-to-fork distribution networks that bridge rural–urban divides and foster place-based food cultures (Everingham, 2021; Murray et al, 2023). Global trade is instead limited to essential goods which cannot be produced locally and where substitutes are unavailable. Internationally, new financial mechanisms channel voluntary North–South transfers through loss-and-damage funds and debt cancellations, sometimes linked to biodiversity conditionalities. Technology sharing and solidarity financing compensate tropical regions for opportunity costs of conservation, and a limitarian account of justice globally sees over-consuming regions, historically in the Global North, seeking to make reparative reductions in their own consumption footprints to allow space for development elsewhere (Bourban, 2025).

Protected Areas

This pathway challenges the dichotomy between “productive” and “protected” lands (Gray et al, 2013; Carmenta, 2023). Low-impact agriculture and forestry maintain sufficient biodiversity to ensure ecological connectivity without extensive wilderness corridors. Strict protection is reserved for highly sensitive ecosystems with low ability to tolerate even minimal human interference. Elsewhere, the KMGBF 30% are met through less strictly protected management options such as OECMs and Protected Landscapes (IUCN, 2008) where they can serve both ecological and cultural heritage functions. IPLCs gain substantial new sovereignty over their territories (Tran et al., 2019), and this is understood as both a moral demand but also an effective conservation measure. Within communities, a new focus on highly participatory democratic principles allows communities to determine PA placement through participatory deliberation that ensures fair burden-sharing, while supporting the *particular* cherished relations that certain communities have with specific areas, landscapes, and segments of biodiversity (Moore, 2023). Global North actors commit to compensate communities in biodiversity rich regions, especially in the tropics where biodiversity is highly spatially correlated with poverty, (Barrett et al., 2011; Maron et al., 2020) for the opportunity costs associated with needing to take on a greater share of the global protected area burden and historic responsibility (Armstrong, 2024; Lenzi et al, 2023).

Sustainable Consumption

Consumption patterns shift through voluntary restraint grounded in egalitarian and limitarian ethics (Cushing et al., 2015; Mikkelsen, 2007). Individuals recognize that reducing consumption in affluent regions enables ecological space and human development elsewhere. Inequality is understood as a driver of biodiversity loss (Hamann et al., 2018; Pandit & Laband, 2009); thus, policies that move towards global equality and meeting everyone’s needs are seen as conservation strategies. Trying to meet needs as locally as possible sees communities switching

increasingly towards circular economy principles, as a premium is put on the reusability and durability of products. Communities voluntarily adopt planetary health diets (EAT-Lancet) and switch towards traditional and local foodways which prioritize what can be produced locally. While decisions are made increasingly at a local level, it is broadly agreed upon that the global economy should facilitate everyone globally, fitting within a “minimum-maximum” consumption window that guarantees every individual a fair share of the Earth’s biocapacity.

Discussion & Conclusions

Our VITAL-Paths-Food represent heuristic visions of what desirable transformative change pathways in global food-and-biomass systems could look like for different perspectives on justice and the value-of-nature, conceived as plausible, archetypical (Sitas et al, 2019), accounts of how a desirable transition could look like for communities or stakeholders with different values and perceptions of justice. These three pathways illustrate how the way we conceive of justice impacts the specific actions we prefer and accept within transitions. Our views on what justice demands influence the kinds of policies and management options we understand to be aligned with our worldviews. The VITAL-PATHS-Food show how three different accounts of justice lead to differences in how pathways seek to reach the same target space. By contrast, there is a risk that scenario studies which incorporate a single vision/understanding/account of justice will miss how justice can act as a variable within the systems being modelled, impacting how all the other features relate to each other. Likewise, the lack of depth and clarity in terminology when justice and human-nature values are brought into scenarios can prevent making these scenario studies comparable.

A limitation of this study has been the challenge of effectively bringing in stakeholder viewpoints for such high-level systems interactions as we sought to explore, which have extremely wide-ranging international impacts which affect almost all people on earth in some way. Unlike in scenario studies at an ecosystem or even national scale, we lacked a pragmatic mechanism for engaging the full range of stakeholders, especially local communities and primary producers, whose views on justice would be needed to develop pathways which fully reflect *actual* views on justice. Doing so would require a large-scale effort to engage in a cross-cultural dialogue which was beyond the feasibility of this study, and likely of most scenario and model approaches. We mitigated this through building our initial scenario drafts around scenario projects (the Sustainable Development Pathways & Nature Futures Framework) which had strong bottom-up stakeholder engagement processes, engaged with “expert/high-level” groups of stakeholders who could give us synoptic views of the thematic areas we were interested in, but also relied on our knowledge of theoretical perspectives on justice and deducing what their normative commitments would be. Our scenarios are therefore “idealized” accounts of how three particular views on justice might envision desirable futures but cannot be said to represent the views of any particular group of stakeholders or “real” beliefs about justice as they are embodied in the worldviews of specific individuals and communities.

Likewise, there is a degree of interpretation involved in determining how general accounts of justice and human-nature relationships translate into preferences for specific interventions. The approach taken in this paper was broadly deductive, i.e., applying our knowledge of applying ethical theories to specific thematic contexts (food-and-biomass systems) and deducing how particular theories of justice may expect them to behave. However, it is difficult to move from this

to making specific prescriptions about what kinds of policies or interventions to pursue without particular knowledge of context, history, what stakeholders understand as the relevant metrics of justice, or where thresholds are perceived to exist.

Additionally, these three pathways are definitionally too narrow to capture the full range of possible value combinations. Within the limits of the operationalizations used here (3 possibilities of each Distributive, Procedural, Recognitional, and Value of Nature), there are 87 possible permutations of justice/value-of-nature scenarios which could have been pursued. Our pathways intentionally left out combinations of value settings judged as less realistic. In our workshops as well, we identified further interest from participants in a locally governed but market-focused pathway that would have combined elements of International Market Innovation and Local Commons Stewardship (and an outline version of such a narrative appears in Deliverable 1.2 of the Rainforest project (Woodhouse, 2025)). The decision not to pursue this narrative further was based on our judgement that this would be unlikely to make sufficient progress on environmental goals. However, further work could focus on testing these assumptions by parameterizing and modelling these pathways to generate impact assessments which could investigate whether narratives that appeal to different groups are sufficient to meet biodiversity, climate, and human developmental goals. In turn, these kinds of impact assessments might be utilized as evidence in negotiations on environmental target setting, allowing parties with competing values/intractable disagreements to understand potential impacts of pursuing change according to their interlocutors' preferences and identify possibilities for compromises (e.g. as proposed by Novak et al, 2026).

We propose these scenarios be used as a heuristic boundary-object for greater future engagement with understanding the justice preferences of groups of actual stakeholder communities in a range of different contexts and scales and locations within food-and-biomass value-chains. Future research could, for instance, explore in greater detail how stakeholders from one thematic area, or in one geographical region, respond to the pathways – how well they track with their own perceptions of justice, or as a basis for understanding what enablers and barriers may exist to embarking on each pathway in specific real-world cross-scale contexts.

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Appendix 1. Comparison Tables

Thematic Area	Narrative	International Market Innovation	Global Sustainability Orchestration	Local Commons Stewardship
Agriculture		Producers are incentivized to find ways of intensifying agricultural production through precision techniques and technological innovation, allowing land to be spared for nature. Market mechanisms such as biodiversity credits and payments for ecosystem services allows the market to price negative environmental externalities and find high marginal utility locations for agriculture and save space for nature in least productive regions.	Sector wide coordination focusses on achieving intensification and economy of scale, through system wide efficiency gains, precision agricultural techniques, investment in logistics and mechanization in order to spare land for nature. Agriculture is globally coordinated through carrot-and-stick incentives to prioritize production in regions with high ecological capacity to bear the costs of intensification.	Agriculture reduces its impact on biodiversity through a widespread shift to low impact and organic production methods. These labour intensive and low input systems foster strong cultural relationships with food production, and people have ties with their local biomes through the food they consume, which is often produced very close to where it is consumed. Agriculture is low yield but expansive, often integrated into semi natural and protected areas.
Forestry		Forests play a central role in offsetting carbon and providing an abundance of material to support a green-growth agenda. Fast growing short rotation stands are preferred to produce as much as possible on the least land.	Global institutions coordinate production and distribution of forests to meet long term strategic ends. Space saving principles are preferred but the reduced impetus on market efficiency allows for longer rotation high-quality wood products and quasi-natural forests	Forests are integrated into expansive agricultural landscapes, and provide a wealth of long-lasting products, and ecosystem services. People have strong relationships with their forests and manage them in low impact, culturally valuable ways.

Trade and Intermediate Value Chains	A liberalized global trade regime flourishes. Circularity of resource use achieved through improvements of waste products. Efficient cost-effective global transport of goods.	Increased role for state actors at the expense of private sector. Global institutes use stick and carrot incentives to pursue developmental objectives.	Supply chains shortened and consumers take a bigger role in organizing production through cooperatives. More goods are produced locally with citizen engagement setting production priorities.
Protected Areas	Protected areas planned to maximize ecosystem service delivery and keep public costs low through the extensive use of biodiversity credits to allow market to identify optimal locations for new protected areas.	Global effort to sparing expansive, well protected, connected areas in areas most vital for achieving biodiversity objectives, and where possible generating ecosystem service co-benefits.	Land-sharing strategy. A few highly protected areas in highly sensitive regions, but protected areas typically include provisions to allow for low impact uses. Globally located
Sustainable Consumption	Overall consumption remains high compared to the other pathways. The focus is on breaking the link between consumption and negative environmental outcomes by substituting harmful products with environmental alternatives, such as novel protein sources. Substitution of products for alternatives reduces need for a strong shift in preferences.	Consumption reduced and reprioritized. Overconsumption in high consuming regions today reduced to make space for raising consumption in others. Governments act to drive down consumption of high impact products via taxes/regulation, esp. in the global north, and reprioritising resource use to support development and poverty elimination.	Consumption substantially reduced as globally consumption switches towards planetary health diets. Citizens of global north countries substantially reduce consumption to allow space within planetary boundaries to allow consumption to raise elsewhere. Shift is primarily demand side driven as values shift towards a preference for using less.