THE PUBLISHING HOUSE
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THE TIME BOUNDARY 2025–2030: THE GLOBAL RESOURCES AND PLANETARY HEALTH TOOLBOX

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Received July 27, 2023

Nature's goods and services are the foundation of life and health. Humans are strongly health-minded, and are individually and collectively resource-driven. However, humans do not frame resources properly, illustrated by predatory economic practices and poor governance across sectors and institutions. The consequence is convergence of cumulative social and planetary state shifts translating into the time boundary 2025–2030. To bring governance systems in line with sustainable use of and fair access to resources we describe a resource systems approach that integrates the concept of planetary health (health for individuals, societies, and ecosystems). To facilitate its operationalization in reaching social goals within ecological limits, the Resource Planetary Health Toolbox has been designed as an instrument in priority setting and decision-making across government and public institutions, economic sectors, and civil society organizations. We show that by bridging the current boundary approaches, the toolbox would operate as a resource – planetary health stress test in all areas of human life and activities. How these can be achieved is explored in an anticipation exercise and through nine recommendations targeting an orderly societal transition. The actual degree of society's preparedness, acceptance, and institutionalization of the approach will inform the range of political and economic options for the future on poverty, equity and democracy, food security and sovereignty, global pollution and biodiversity erosion, and climate change.

Keywords: Adjusting needs and resources; Demography; Resource justice; State shifts; Universal social protection floor.

INTRODUCTION

Nature's goods and services are the ultimate foundation of life and health. Humans are strongly health-minded (Panel 1), and are individually and collectively resource-driven, yet frame resources incorrectly because public and private resources are unsustainably managed and ill allocated (Panel 2; Figure 1A).

The short view has so far prevailed. With a surfeit of science and policy, today's agendas deliver contrasting and confusing socioecological future visions. Taking the long systemic view[1,2] requires focusing on:

(1) Convergence between social and ecological issues[3–6] with emphasis on inclusive health[9].

(2) Valuation of the benefits that ecosystem capital delivers to human well-being / health[10,12–15]. The continuous depreciation of the capital has become societally harmful, revealing cumulative tipping points and compound risks.

(3) Building the social foundations of equity, equality, and justice on normative questions of

resource and opportunity distribution[16], *i.e.*, public policies dedicated to fairly adjust resources and needs[17–19].

It follows that resources and health are a problem – solution dilemma (Figure 1) that has to be addressed on both the short and the long term.

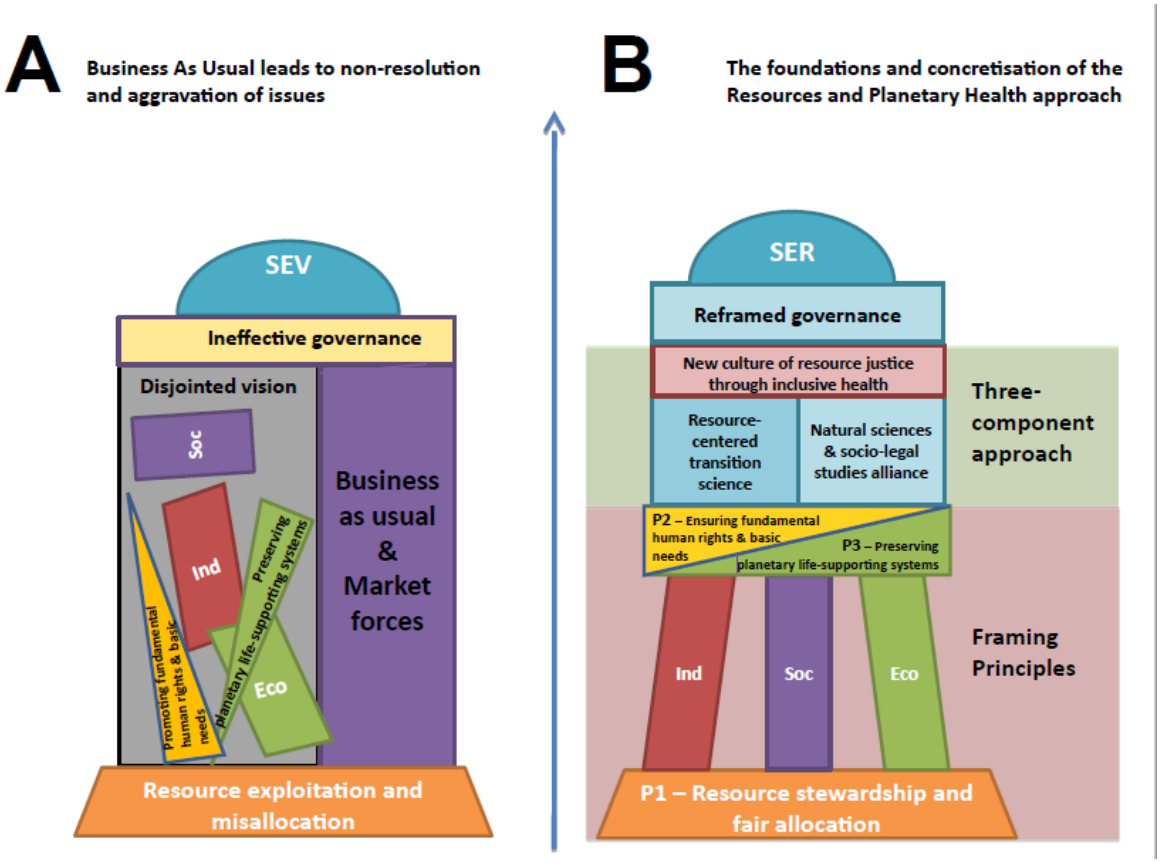

Figure 1. Business as usual *versus* the Resources – Planetary Health framework.

(A) Illustration of the current short view situation that reveals a disjointed perception of coupled social and environmental challenges. Conflicting agendas generate inadequate policies and foster unsustainable resource governance leading to increased socioecosystemic vulnerability (SEV).
(B) The Resources Planetary Health long view design. Reframing the natural resource governance consists in the articulation of the three universal principles (P1, P2, P3) and the "inclusive planetary health" pillars (Ind: individuals; Soc: society; Eco: ecosystems), operating as an integrated analytical tool. On these foundations, the resource systems approach is built as a science and society co-construction. The entire edifice participates in the emergence of new cultural frames and narratives to guide transitions toward socioecosystemic resilient societies (SER) through resource justice and responsible governance.

In a context of conflicting legal regimes and national capacities in a resource-constrained world[20–25] and the spreading of innovations and technologies that promote social justice while taking into consideration environmental limits[27,28,31], the main questions are:

How to allocate accessible resources in ways that reconcile the basic needs of populations with the maintenance of the life-support functions of ecosystems?

What forms of legal powers should be held over natural resources and what legitimacy instruments should be designed to balance resource justice versus market forces?

What are the social and ecological determinants of health and how are the health co-benefits and co-harms evaluated in decision-making?

ACTING IN THE ERA OF STATE SHIFTS WITHIN THE TIME BOUNDARY – THE RESOURCES PLANETARY HEALTH TOOLBOX

To address these questions, we considered the following concepts in a socioecological and multi-disciplinary perspective: global resources (land, water, and biomass in particular), planetary boundaries,

societal boundaries, planetary health, critical zone, food systems and global pollution, resource allocation and market forces[9,29–31,32]. They help understanding how current policies enforce state shift conditions in a range of social and ecological contexts and accelerate the radicalization of challenges[33–37].

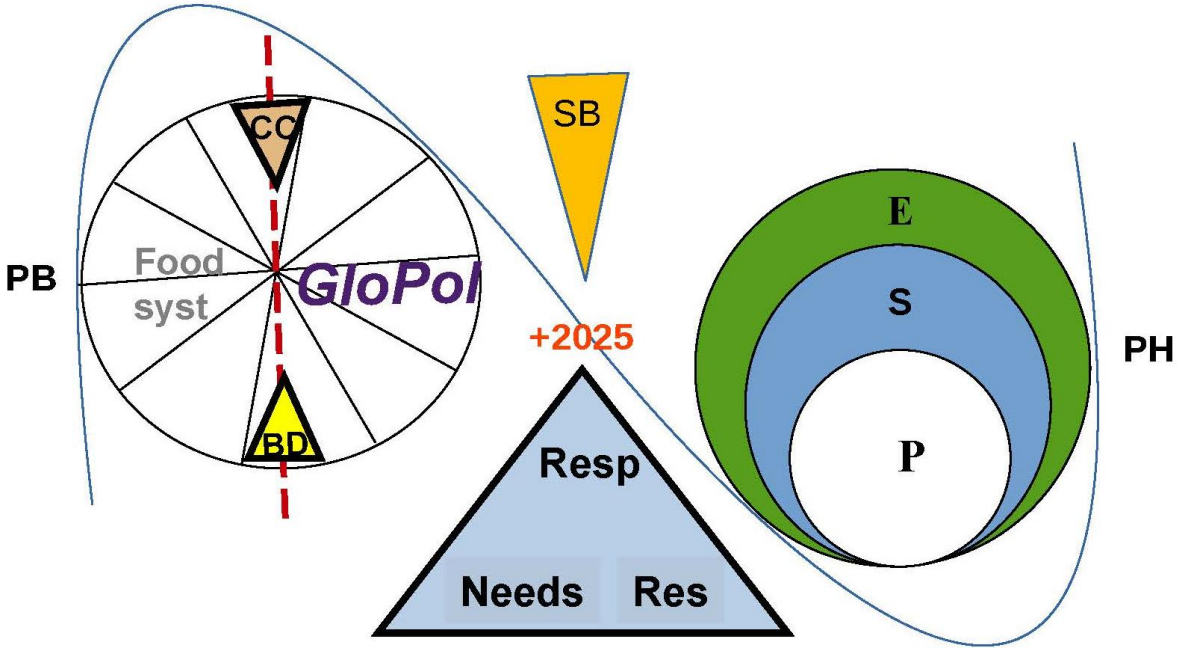

Figure 2. The time boundary 2025–2030 framework.

Planetary Boundaries (PB diagram) have been aggregated in two subsets of interacting boundaries: food system (Food Syst) and the physico-chemical (global pollution, including waste, GloPol) disruptions. Climate change (CC) and biodiversity (BD) variables overlap Food and Global Pollution system boundaries (inserts in PB). Together with Societal Boundaries (SB) as reflected in the resource landscape, they are operating under cumulative state shift regimes, *e.g.*, resources and pollution/waste, soils and water, population and carrying capacity, land use change and per capita economic indicators (the sygmoid). The Planetary Health framework (PH diagram), the indivisible health of ecosystems (E), society (S), and people (P) imply coherent and immediate trade-offs between social and ecological health through the Responsible adjustment of Resources and Needs (Resp, Res, Needs triangle). That requires amortizing the consumed socioecological capital by making effective the real costs of commodities and labor in the global economy. Coupling resources and PH becomes a narrative and metrics of the common purpose across boundary systems. (Adapted from Negrutiu, 2022).

The resulting framework (Figure 2) sets focus on the socioecological time boundary at the junction of global disruptions and cumulative state shifts. It indicates that:

(1) State shifts are presently converging within the 2025–2030-time window[9,28,35]. This means that with current life styles and technologies we are fast approaching the time boundary, main stressors being the food systems and the global pollution.

(2) Vulnerable socioecosystems relate to carrying capacity pressures[36,38] at a time when resource sobriety and justice are expected to act faster than demographic dynamics and policies[39].

(3) With the global population having reached eight billion in 2022 and more than half of global ecosystems being strongly anthropized[35,40], global resources and planetary health are directly impacted, albeit in context-specific manners.

(4) Balancing and managing planetary and societal boundaries requires integrating planetary health with global resources (Panel 3) according to inclusive social and ecological governance regimes[2,7,41]. Needs and health are the culmination of the management of the resource base[9,42].

The integration of resources and planetary health implies measuring what counts for ruling according to what matters, *i.e.*, adjusting the balance between management through numbers and governance through law[43]. To operationalize the resource-planetary health approach we designed the Resources Planetary Health Toolbox (RPHT; Panel 3; Table 1; Figure 3). Specifically, the instrument allows to methodologically integrate the assessment of planetary and societal boundaries, namely assessing the health state of resources, all combined.

Table 1
Comparative of resource and governance components in Common Pool Resources (CPR) and Resource Planetary Health (RPH)

In both approaches the socioecological (SES) context matters with respect to dynamic processes of knowledge of the state of resources, rules of sharing and conflict resolution mechanisms, and institutional and control instruments.

Components of SES framework	Common Pool Resources	Resources Planetary Health Toolbox
Resource system	Community resources, such as forests (mangrove, wood), grazing land, costal zones, water systems, fisheries. Resource units.	All resources combined, local-to-global. Protocols to monitor planetary health variables.
Governance system Resource rights framework	Nested frameworks of users / actors, interactions-coordination-confidence, rules, outcomes. Political, government, and market environments.	Three principles (Figure 1B) guiding public, private, and community interests to converge on resource responsible stewardship and justice on the short-to-long term.
CPR versus RPH	Allows understanding the emergent properties of combined resource and governance systems based on the taxonomy of nested variables. Provides detailed frames for design, elaboration, implementation, follow-up of resource management projects. They can benefit to RPH at local to national scale.	Is a conceptually simple "quick start package" tool across administrative and geographical scales. Can enforce the efficiency and fairness of CPR regimes, but also the defense of communal property rights where endangered by market pressures, resource scarcity, population growth, conflicts, etc. CPRs can benefit from Planetary Health metrics and monitoring,

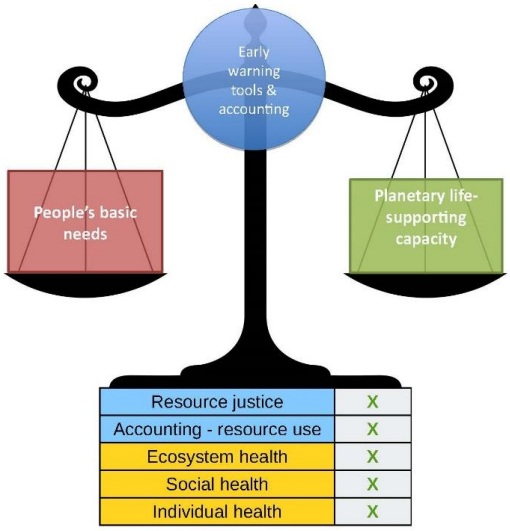

Figure 3. The Resource Planetary Health Toolbox is an instrument designed to assist stakeholders arbitrate between different socioecological scenarios and options for short-term to long-term trajectories.

The dashboard (a systemic frame of resource and governance regimes) is used to adjust resources and needs supported by RPH metrics, i.e., headline indicators. At local levels, the dashboard integrates Ostrom's social, economic, political settings, interactions, and outcomes approach (Ostrom, 2009) and our protocols according to Figure 4 and Figure 5. RPHT operates as a stress test and early warning signal through which projects, activities, and territories must simultaneously check positive for resource justice, resource (over)use accounting, and planetary health components, while leaving the stakeholders the task of making the appropriate decisions to meet the target(s).

Table 2 assembles the 5–10 year and beyond projections and priorities. The emerging picture constitutes an anticipation exercise on whether we are or we are not acting in accordance with what we know, and whether the commons and sustainability are going to prevail. The ambition is to foster the emergence of a new economy of natural resources coupled to resource justice[18,44]. In that economy the costs of implementing integrated resource stewardship and fair allocation are likely to be commensurate with the potential cost saving effects on the planetary health system. The supportive science makes the object of Sections 3 and 4 below.

Table 2

The decades ahead through the lens of the Resources-Planetary Health Toolbox (RPHT)

Actionable anticipatory projections are built on the premise that responsibility is a potent anticipatory driver in identifying priority areas. It is setting the baseline on accounting for the full ecological and social cost of human activities, e.g., amortizing the consumed socioecological capital by shaping the range of societal options in key areas on the short and long term. Insurance instruments and anticipatory investing modeling are needed along the entire RPH process. Resources and planetary health are strong education and pedagogic tools.

5 years	*10 years*	*10–25 years*
Co-construction of the platform on resources and planetary health (RPH) and organization of a RPH summit (cf. Table 3). Measuring what counts: institutionalization of resources and planetary health open source data systems (findable, accessible, interoperable, reusable).	Linking health and wealth in distinct societal contexts: translate into targets and deadlines the limits and trade-offs of the adequacy between the sustainable supply and the societal demand on global resources.	Leave open the greatest number of political options with positive feedbacks on the commons and social justice by systematically promoting holistic science and education.
Instruments for resource justice and ecosystem-to-biosphere stewardship (the commons): monitoring, reporting, standards, norms, protocols. Enact the Universal Social Protection Floor.	Enacting resource justice to balance limiting resources, basic needs / poverty, social cohesion, demography (i.e. no social and ecological dumping). First targets: food - energy security and making land, water, biomass common pool resources.	Based on the RPH approach, define strategies and anticipate resources and technology needs for the maintenance and / or transformation of public services, institutions, and infrastructures.
Modeling RPH costs, benefits, and risks. Dashboard of indicators to systematically monitor and evaluate PH degradation/ improvement, locally and globally (with emphasis on global pollution).	Stress tests on RPH friendly technologies and policies. Deploying technologies that help address the environmental limits and support social and resource justice.	Ethical, cultural, political, and economic issues in the light of the common purpose (values and principles of shared societal responsibilities and technological literacy and wisdom).
More generally, explore the Limits to growth predictive scenarios (Meadows et al, 2005) with RPHT to assess demographic and carrying capacity issues in particular.	Reduce resource depletion and pollution / waste per capita (Mote et al, 2020). Real costs of commodities and human activities become the norm.	The diplomacy of a manageable togetherness based on the diversity of cultures and narratives. Facilitated by the fact that all cultures share concerns about health and resources.
Elaborate (continuous) education and training programs on RPH in conjunction with trans-generational conversations.	Generalize (continuous) education and training on RPH.	Who owns Nature in the end?

THE SHORT-TERM PRIORITIES START WITH ADJUSTING ACCESSIBLE RESOURCES AND BASIC NEEDS *VERSUS* THE MARKET

The most straightforward way to act upon the time boundary stressor is through improving the aligning of equity in wealth within the limits of the biosphere. The adjustment of accessible resources and fundamental social and economic needs with a responsible maintenance of the life-support capacities of the biosphere at all governance levels has occasionally gained attention in societal debates (Panel 4[9,17,45,46], see also[47]). Nowadays, it has lost momentum across current political, diplomatic, and global institutional spheres. We therefore bring the issue at the forefront of our work by considering that, in a socioecological perspective, the adjustment of resources and needs ought to be the "first law of life". The Resource Planetary Health systemic metrics and the enactment of binding legal instruments that (1) ensure fair access to resources for all (resource justice), (2) impose accountability for resource over-use and degradation, and (3) achieve sustainable levels of resource use (Figure 3) provide a mechanism.

Such a radical change implies questioning the current missions of the market, science, organizations and institutions, and working toward the emergence of institutions that encourage equity and responsibility by creating positive feedback loops that prevent the efforts to undermine them[4]. For example:

(1) Questioning the hypothetical resource optimization through the autoregulatory supply – demand mechanisms of the market do not exclude the rules of adjusting supply and demand, *i.e.*, the rules of the market. Rather, the classical distinction between the formal (market) economy and the substantial economy[44] gives room for maneuvering to States to regulate the propensity of the market to avoid accounting for unpaid or low-cost work of both humans and nature in the circuit of capital and the circulation and distribution of wealth.

(2) Designing principles and instruments able to change priorities at a time when the resource

dependency of social systems is accelerating and social tensions are amplifying (Panel 4; Figure 1B). For example, the 2008 crisis and the Covid-19 pandemic have shown the need to turn (universal) social protection floors[49] into permanent measures through structural changes in the governance of the commons and the commodification of socioecological systems by the market[50].

On these grounds, the following priority research agenda on socioecological and technological innovations identifies local (sections "Providing systemic instruments" and "Making cost-benefit evaluations systematic – on traceability") and global (section "Legal, regulatory, and normative coherence and convergence in administrative, institutional, financial, investment, and economic decision-making settings") directions of work.

PROVIDING SYSTEMIC INSTRUMENTS

The objective is developing tools for policy decision and regulatory impact analysis that strengthen monitoring, assessment, planning, implementation, reporting, and review capacity of the state of resources and facilitate the rationalization and scaling of social, economic, environmental, etc. projects.

For example, tools to assess the state of physical resources at national and subnational scale, *e.g.*, ecosystem health, have been reported[32,51,52], see also the work of National Academies on social and ecological determinants of health[53], as basis for the US program to assess nature loss by 2026[54], and the interface between social and ecological health has been updated[16,36]. Such instruments would enable

– (near) real-time and systematic diagnosis of the state of ecological capital (land, water, biomass, energy, etc.; *e.g.*[55,56]; https://www.earthdata.nasa.gov/learn/use-data/tools) to accurately measure externalities and monitor trends for basic requirements for populations so as to define caps on resource use and target no net ecosystem degradation.

– the translation of environmental limits into targets and deadlines by supplying know-how that provides sustainability-proof technologies with standards and certification, thus guiding decision-making to avoid, or at least to compensate for, social and ecological deficits.

The SUSTAIN program in Norway[57] is a case in point. Dealing with the multi-actor stewardship of aquatic resources (Figure 4), it is based on an iterative process of comparison, evaluation, and improvement providing harmonized input data and shared simulation protocols.

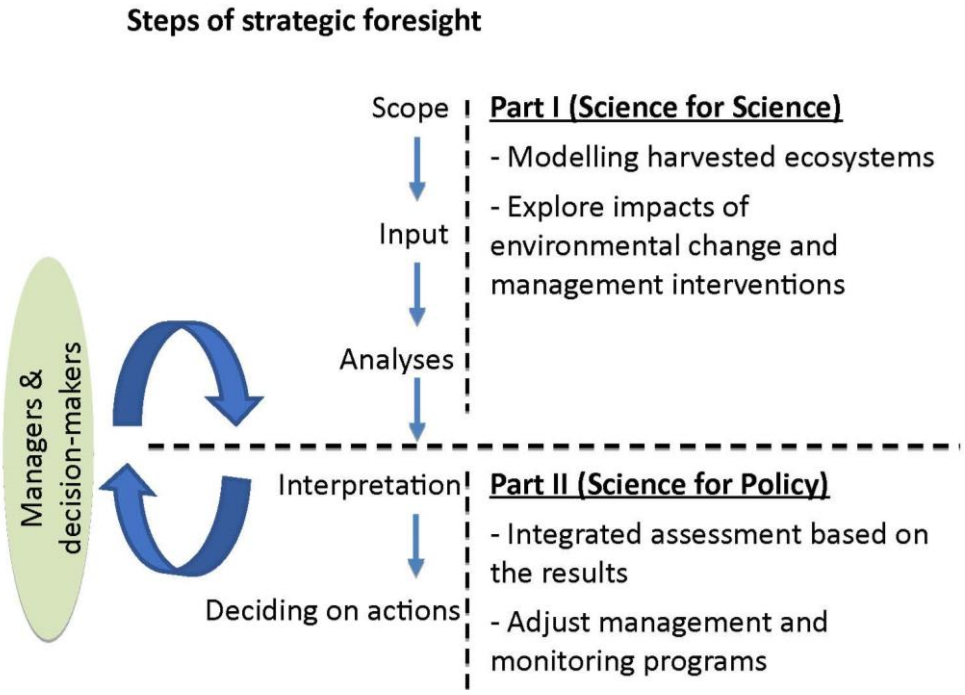

Figure 4. The SUSTAIN program, a precursor of Resources Planetary Health toolbox.

SUSTAIN (2022) is a national initiative in Norway for integrated harvested animal resource management through biomass stewardship. SUSTAIN was founded in 2015 to address the poorly understood interactive effects of how exploitation and climate changes affect different harvested ecosystems in marine, freshwater, and terrestrial settings, and to evaluate how management strategies can ensure the systems remain sustainable and resilient.

The working model consists of two parts organized in an iterative feedback loop that can operate indefinitely to keep the system responsive. This allows evolving and long-term protocol design. The Part I includes the development of theoretical and empirical ecological models for systems under exploitation. In Part II, the response of models in Part I are evaluated together with end users (made up of managers, decision-makers, and institutions involved in the management of harvested ecosystems) to develop management system evaluations and scenario planning outputs, which are then re-integrated into the ecological models in Part I.
The program explores multilevel feedback loop, learning, and negotiation processes in the social system in response to changes in the ecological system. This includes information sharing, deliberation and self-organization activities and rules, monitoring, and sanction mechanisms in policy development. Thus, it provided an opening to further build social capital. The research program is detailed at https://www.sustain.uio.no/.

MAKING COST-BENEFIT EVALUATIONS SYSTEMATIC – ON TRACEABILITY

In order to ensure that the costs of implementing resource stewardship and fair allocation are commensurate with the cost saving effects on the planetary health system, planetary health assessments must account for the full ecological and social cost of human activities (Figure 3). More precisely:

(1) Evaluate the ecological costs / benefits of social innovations, such as enacting the universal social protection floor – a major component of social health[9]. That can be explored with indicators that reflect planetary health dependencies, *e.g.*, economic gains derived from ecosystem and public health improvements[58,60,61].

(2) Assess the adequacy and examine the trade-offs between the sustainable supply (ecological stocks, regeneration rates of resources) and the societal demand (needs) across geographical and administrative scales. To that end, provide protocols enabling relevant decision-grade information to flow across sectors and scales (thus guiding and resolving normative conflicts and institutional fragmentation toward policy coherence).

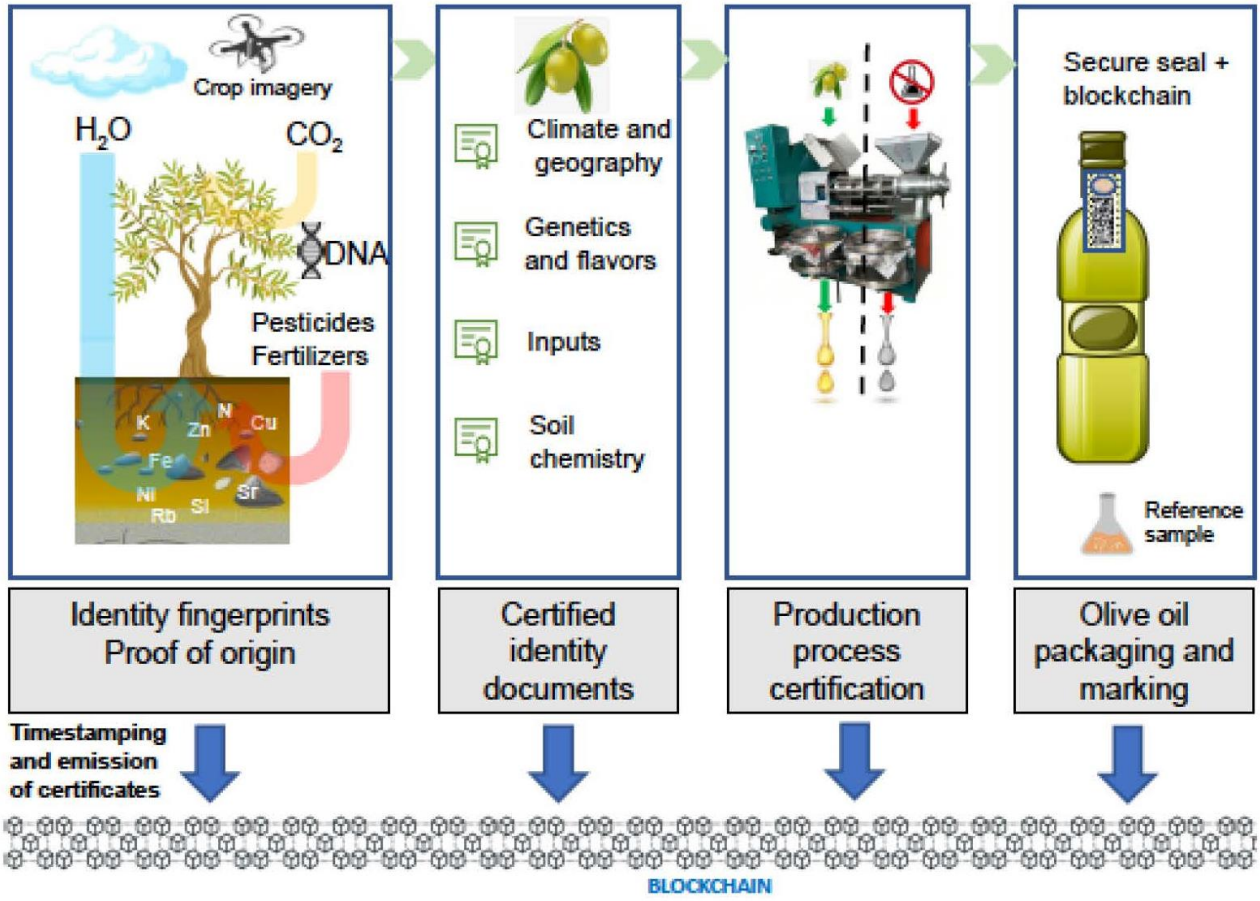

Figure 5. The food system as economy of trust - the "DNA" of everything.

The working model draws on the variety of signatures in food systems to design the sequence of identification, authentication, tracing, and tracking along the entire process of production to ensure the traceability, compatibility, and auditability. The challenge is to protect

resources, brands, and margins for farmers to agents to subcontractors to suppliers in the food production, processing, and marketing chain all the way to the consumer. The model is an avatar introducing the tools and data that enable to monitor the commitments made by each party and make the players more accountable. The notions of authentication and traceability become key to guarantee, for example, the quality and conformity of products. They are multifaceted: biological identity (DNA signature) and proof of origin (a signature of the location and growing conditions, such as the nature and quantity of inputs), and the integrity of data and processes throughout the production and the downstream chain. The digital process links these processes and results in a system that protects the producer and the consumer and makes the system auditable from end to end. Blockchain technologies, complemented by artificial intelligence tools, make it possible to follow the "data pipe" that underlies all transactions, from the primary product (*e.g.*, olives) to the product reaching the consumer (olive oil).

Such a double socioecological costs / benefits evaluation is expected to both facilitate aligning nature-related non-linear and compound risks with current risk categories[62] and set the balance right between stewardship and ownership of defined resources[63].

A supportive protocol designing an "economy of trust" is shown in Figure 5. The economy of trust is a component of planetary health as it jointly mobilizes the State, the citizens, and the corporate with the aim of tracing the life history of resources, products, waste, and pollutants. This implies changes in the chains of responsibility for product, process, and practice quality and monitoring to the benefit of improved auditing and transparency. It therefore requires reconsidering the entire supply chain and demands that standards and practices be put in place by all players ensuring social equity through benefit sharing, and thus viable economies and fair politics[64]. Food, health, and energy systems, and their reliance and affordability in particular, are main target areas. For example, monitoring production and consumption patterns in food systems would provide means to (1) better understand the many interactions between food-health-environment, (2) call into question the hierarchy of current priorities, and (3) reveal and quantify the corresponding economic and social trade-offs.

LEGAL, REGULATORY, AND NORMATIVE COHERENCE AND CONVERGENCE IN ADMINISTRATIVE, INSTITUTIONAL, FINANCIAL, INVESTMENT, AND ECONOMIC DECISION-MAKING SETTINGS

Informed by the above tool developments, enforcing the authority of the law (*e.g.*, elaborating the frame of norms, standards, protocols, certification, and labels) is of particular significance for the stewardship of territorial resources and for providing populations with fair access to those resources (Table 1). This implies:

(1) Identify blockages within international law (in particular trade and international investment laws and treaties) which, either in the content of the rules or in their interpretation, have the effect of limiting, slowing down, or even preventing States and their local authorities from developing public policies to adjust resources allocation to the socio-economic needs of their populations.

(2) Study how to build networks of alternative institutions and organizations with socio-ecological holistic foundations and broad stakeholder involvement. These networks will be legitimate to evaluate, report, and account for the state of global resources, their allocation, and conflict resolution.

To those ends, a global Resource Planetary Health agenda is designed to challenge the mainstream political, financial, economic, or diplomatic agendas. Table 3 assembles the concepts, instruments, and organizations that question the current missions of global institutions. We show that the underlying science of priorities is building up by benefiting of an enlarging body of laboratories, centers, institutions, and organizations engaged with research and knowledge production on resources, planetary health, and ecological transitions. Of note, beyond western science and agendas the Chinese approach known as the ecological civilization deserves attention; it mobilizes the principle of "Unity of Man and Nature" (Panel 5).

Taken together, we estimate that the conditions are met to set up a Resource Planetary Health task force for a global scale action comprising stakeholder consultation and deliberative learning, followed by a validation summit to implement an integrated dashboard of planetary health indicators. Achieving consensus or at least creating synergies can have positive feedbacks on the myriad of transition initiatives around the world[27] and could be a prerequisite for networking them.

Table 3

Closing the global resources-health science and policy gap

Emphasis is put on governance structures and institutional quality attuned to resource governance AND health. Questioning how social, economic, etc., organizations work allows governance across sectors, justice, and sustainability to be challenged when decisions made today will detract from the health and resources of tomorrow. How these two realms can be coupled operationally in political decision-making is attempted here. The articulation of Planetary Health (Frame 1) and resource stewardship principles (Frame 2) – called the Resource Planetary Health Toolbox – aims at addressing socioecological vulnerability by implementing a system of resource-to-needs adjustment by the public power to which the rule of the market is subordinated. Implementing a right-and-duty responsibility driven process is therefore conceived as a multi-stakeholder platform and task force working toward the federation and integration of current models, instruments, tools, indicators, protocols, norms, and standards within a maturing data science and observatory networks. For example, the listed headline indicators are essentially global and have macroeconomic significance. The platform would perform the preparatory work of, for example, a joint COP on Global Resources and SDGs supported by the design outlined here: managing contestation between the public good, private sector demands, and competing political interests. Institutions and organizations with coordination missions are specified.

Process/ Notion/Mechanism	Instrument, tool, protocol	Coordination frame/ Remarks	References
Frame 1 - Health triptych			
Ecosystems (Half Earth proposal and beyond)	Environmental Performance index; Environmental evaluations, monitoring, reporting.	UNEP, FAO, IUCN State of global resources; Planetary Boundaries.	Steffen *et al*., 2015; Hsu, 2016; Haines *et al*., 2018; IUCN, 2019; Ellis, 2019; OECD_UNECE, 2020.
Society (Human development and Global health)	Human Development Indicator (HDI); Better Life Index; Index Social Health (ISS); Global health status; Social Progress index (SPI); Social development indicators; GINI index; Global burden of disease indicators.	ILO, UNDP Weak sustainability: median income to inflect GDP; Strong sustainability: Universal Social Protection Floor as baseline.	UNDP, 1990; WHO 2015; ILO, 2014; Tulchinsly and Varavikova, 2015; OECD, 2017; SPI, 2019; WB, 2019; Banerjee and Duflo, 2020.
Individuals	Public health: core health indicators / global health indicators. Material standard of leaving.	WHO The capability concept.	EU, 2012; Ottersen *et al*. 2014; WHO, 2015; SEN, 2016; UNEP, 2016.
Planetary health, all-in-one	Genuine Progress Indicator; Sustainable Development Index; Carrying capacity (HANDY) and China's Ecological civilization monitoring; Impact inequality indicators. Comprehensive wealth. Coupled human-ocean health index.	New entity, inspired by Resource Management Act of New Zealand and UNEP/IRP; Precepts, standards, guidelines of the Natural Resource Charter; Safe and just space; Aggregated indices / indicators facilitate comparisons (with reference to Limits to growth scenarios and HANDY modeling).	RMA, 1991; Meadows *et al*., 2005; Natural Resource Charter, 2010; Halpern *et al*., 2012;Whitmee *et al*., 2015; Raworth, 2017; Hickel, 2020; Mote *et al*., 2020; Dasgupta, 2021; IISD, 2021; Zuo *et al*., 2021; Rockström *et al*., 2023.
Frame 2 – Resource adjustment triptych and Principles			
Fundamental goods (commons)	Social costs / benefits of ecosystem health	New entity inspired by the Havana charter on food systems; Sustainable levels of resource use.	Havana Charter, 1948; RMA, 1991; UNEP, 2017; Fischer-Kowalski and Steinberger, 2017
Basic needs	Ecological costs / benefits of social health	UN economic and social Council; Accountability for resource over- and misuse.	Gough, 2015; see also SPI 2019; Mahon, 2018; IUCN, 2019; Hickel, 2019.
Fundamental rights	Idem	UN human rights mechanisms; Resource justice.	
Conflict resolution in policy decision-making			
Strong sustainability and sustainable welfare; Trade-offs constrained by "No net ecosystem degradation" as baseline.	Environmental and social performance indicators; Science-informed protocols with enforced accountability along the entire players chain, in particular on global pollution and waste.	Availability of effective statistical frameworks; Dashboard metrics and protocols are context meaningful; Modeling nature dependency for countries and sectors.	Shmelev, 2017; IUCN, 2019; Fairbrass *et al*, 2020; Banerjee and Duflo, 2020; Hirvilammi and Koch, 2020; WEF, 2020; Wang Z *et al*, 2021.

ARTICULATING THE SHORT-AND LONG-TERM TO MAXIMIZE POSITIVE FEEDBACKS

Table 2 recalls the main objectives and the means to achieve them. The beyond 10 year time jump highlights the main political, technological, institutional etc. guidelines. It has a great deal to do with the place technology and social issues hold in projecting the future. Confronted with social systems unpredictability, one can anticipate that

(1) Socially fairer societies will tend to be more resilient then less equitable / egalitarian ones[36]. For example, questioning technological determinism and solutionism[28,97] in the double game of power between China's state centralized capitalism and GAFAM's private centralized capitalism means understanding how technical tools and systems (a) change the perception of the world and structure the social space, while preparing the horizon of new technologies, (b) may restrict democratic debate and practice with the risk of an insufficient ethical response and impoverishment of world narratives and visions, and (c) are unlikely to create conditions for an "ideal" governance but maintain the risks of (soft) alienation.

(2) The technological progress (or rather progression) needs to be mastered and channeled by making coherent choices of technologies that address the environmental limits and support social justice (*e.g.*, no ecological and social dumping; see also[98] while scoping the market and investment toward nature-based solutions (such as reducing raw material inputs and waste/pollution[16,80,90]. In this, resource sobriety and inclusive health are becoming cultural driving factors. That culture is built on technological and environmental literacy[99–101]. Such a transformation implies profound changes in ways of thinking institutions, practices, science and technology, policies and diplomacy, lifestyles and education.

(3) The world order to come will be confronted with the food-energy-pollution constraint as the baseline. Local to global negotiations and conflicts on land, water, and biomass issues, with corporate multinationals in strong position (https://booksandideas.net/Who-owns-nature.html), will become widespread and will affect many other sectors of activity. For example, the land use change and rhythm of change remains the main factor of past and forthcoming socioecological state shifts[31,35,36,46,65].

(4) In the context of Romania, we highlight the more specific issues recently reported on food systems, nutrition, pollution, and health on the one hand (Proc. Rom. Acad, 2025), and social aspects of health relating to natality, demographic factors, and family health on the other hand (Proc. Rom. Acad., 2024). Integrating the identified public health priorities of the country within the broader resources-planetary health frameworks reported here is expected to deepen the building up of current interdisciplinary capacities.

CONCLUSION AND PERSPECTIVES

With resources and health standing at its core the Resource Planetary Health Toolbox is

– a socially constructed pragmatic, preventive, and non-prescriptive enabling approach designed to delay, reduce or offset the effects of cumulative state shifts (Figure 2);

– a straightforward and science-informed instrument bridging current boundary systems and aiming to challenge the social and ecological dumping by braking down the economic, social, and political drivers of lock-in and creating enabling environments through synergies and trade-offs in decision and cooperation;

– a "one-size-fit-all" instrument translating guiding principles and indicators (Figure 1B; Table 3) contextually in a wide range of pathways according to place-based cultures, resources, and governance (for example, through differential institutional logic of allocation, redistribution, and stabilization functions). The baseline toolbox would consist of a set of World Health Organization indicators for individual health, the universal social protection floor state indicators for social health, and ecosystem capital accounts for land, water, biomass, and ecosystem infrastructure for ecological health.

The approach will have its share in the current science-to-policy landscape (Table 3[28]) because it answers to crucial questions and provides a common language, directions, dedicated tools, and an important corpus of legal and regulatory instruments, thus helping closing the resource-health science-to-policy gap.

In a broader perspective, Resource Planetary Health together with New Zealand's Resources Management Act and China's Ecological Civilization reveal the essence of the socio-ecological approach. Such political instruments awaken

– the need for science-informed anticipation in the identification of trajectories of change,

– the need to increase knowledge in order to better articulate objectives and tools, and to channel capacities for action (*e.g*., socioecological planning, transparency, and accountability), and

– important questions about pressing challenges, namely integrating the long term issue in science and society, and reframing the world order organization and the market in the face of converging global issues (in particular pollution and waste, inequalities, epidemics, migrations).

RECOMMENDATIONS

The adjustment of resources and needs is the entry point in scoping the role of the market in resource allocation and in targeting the time boundary (Table 2). The following recommendations address the challenge.

(1) Start with enacting and implementing the universal social protection floor[49]; with priority on farmers rights104 and making land, water, and air common goods.

(2) Prioritize food and energy security while integrating demographic issues, the ground zero of the relation of food, soil, water, and health to labor-power condition, and – as such - the landmark of the food-health-environment nexus. Science, technology, and society have a range of solutions at hand to make public policies and regulatory instruments work in production strategies and consumer behavior through incentives, norms, standards, etc. (Figures 4 and 5[31,36,105,106,107,108]). The expected outcome would be enhanced food security and rights-based food sovereignty[109].

(3) Put climate change inside the global pollution-waste challenge[9,90,110] (Figure 2) for which, contrary to food systems, science has no silver bullet to tackle the changing and cumulative combinations of man-made chemicals[96,111,112,113]. They constitute a too high-cost burden for planetary health and the economy itself. Therefore, solutions must be addressed politically, socially, and economically with the clear objective of chemical simplification[30,114].

For these to enter the main political and diplomatic agendas:

(4) Organize the multi-stakeholder Resource Planetary Health platform and summit to co-construct and validate the one-size-fit-all toolbox (indicators, standards, norms). A great deal of the work can benefit from the IRP/UNEP resources (Panel 2).

(5) Translate the platform work into Resource Planetary Health assessments in national accounting systems as a complement to GDP metrics. The Resources Management Act of the New Zealand[81] offers a real-life legal framework (Panel 2).

(6) Use the Resource Planetary Health Toolbox in systematic local-to-global comparisons to provide science-informed arbitrage protocols when competing or conflicting socio-economic, institutional, or territorial interests are at stake, and to inform economic actors on the resource environment in which they operate.

A general prerequisite for making the above fully actionable implies

(7) An urgent and coherent change in public data policies, with focus on Resource Planetary Health metrics that needs to be findable, accessible, inter-operational, and reusable[115].

(8) Such data systems need to be exhaustive, regular, reliable, transparent, and verifiable, and have precise geographic details (see the economy of trust issue, Figure 5).

(9) Once processed, decision grade information can be explored in policy choices, economic models, investment strategies, etc.

PANELS

PANEL 1 – HEALTH, THE INCLUSIVE ISSUE

The strength of the notion of health stems from the capacity to encompass the societal metaphoric meaning of health, the universal values that it harbors, and the actionable, factual, scientific evidence-based policy dimension of public health (individuals, societies), and the state of ecosystems. In other words, the inseparable health of nature-society-people, known as "planetary health"[84,116], see also[117]. The inclusive health approach is likely to be understood, accepted, and shared locally and globally.

More precisely, health is a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity[118]. A socially just and environmentally responsible society ought to consider that Health is a precondition, outcome, and indicator of a sustainable society, and should be adopted as a universal value and shared social and political objective for al[l78]. Ecosystem health refers to ecosystem condition or state and implies maintaining the system's organization, functions, diversity, productivity, resilience to stress and autonomy over time. Ecosystem degradation is

often expressed in economic terms: ecological recession / degrowth / meltdown. The ecosystem health is therefore a strong determinant of social and personal health. For example, health care costs attributable to environmental risks have been estimated at nearly a quarter of deaths and disability-adjusted life years penalties[58].

As methodology, the planetary health makes the three categories of health indivisible, interdependent, and reciprocal by providing science-informed and technology-enhanced actionable capacity in local-to-global contexts needed in socio-economic models and investment strategies (*e.g*., diagnostic protocols, standards, and norms, and monitoring, traceability, and reporting tools[119].

PANEL 2 – RESOURCES, FOSTERING TRANS-SECTORAL AND INSTITUTIONAL STEWARDSHIP OF THE COMMONS

Resources are defined as inclusive physical, human, economic, institutional, normative, financial, technological, digital, etc. capacities through which collective and individual agency operates within societies[9]. Time becomes a cross-cutting resource of all.

Resources, including the human resource, are the matrix of economic and political power systems, of history's ups and downs, and they have great geopolitical sensitivity. They are the substance and driver of economic models and institutions (the nutrients of the social ecosystem) and are a precondition of sustainable societies. Natural resources operate as socioecosystemic signals of planetary health and as such reflect specific historical natures. Resource overexploitation and strong economic stratification are structurally enshrined in social relations and mentalities[24,41]. They can end up in societal decline and collapse, as documented along history[120,121].

Are we reaching one such milestone when considering the current amount of human-made mass and the rate of its fabrication? That anthropogenic mass (mainly concrete, aggregate, bricks, asphalt, plastics) exceeded in 2020 and for the first time the dry weight of all life on Earth, *i.e*., the combined biomass of humans, animals, plants, fungi, and microorganisms (about 1.1 trillion metric tons)[122,123].

In addition[124], have analyzed the synergic effects between and within "old scarcities" (fertile land, freshwater, energy, phosphorus) and "new scarcities" (environmental degradation/biodiversity loss, time for transition). The political, social, organizational, institutional, and economic determinants of scarcity raise concerns about the future availability, acces-sibility, utility value, and distribution of resources. For example, resource scarcity-generating institutions create profitable scarcities and resource overexploitation leading to infringement of freedom, social inequity, and environmental degradation (see also[105]).

The prodigious work of the International Resource Panel[18,46,80,90] and its recommendations have had no effect on business as usual so far. Why? The roots of the problem lie in the effective supremacy and protection of exclusive property rights (material and immaterial) to the detriment of vital needs and interests of populations[29,64,106]. For example, the maldistribution of rents from natural resources is grounded in institutions and political economy despite the fact that in most national constitutions and under international law natural resources are common property resources[22,44,125]. Because of the supreme status of human rights in international law, the legal aspect of natural resources as a human right grants people equal and non-discriminatory access to common property resources.

In this landscape, the New Zealand's Resource Management Act[81] is a transgressive and pioneering reform in environmental law creating an integrated natural resource sustainable management system at the apex of the country's legislative hierarchy to direct all other policies, standards, plans, and decision-making. For example, spatial strategies of territorial management are designed within natural limits defined by rules and norms. One main reason is certainly the by now documented fact that 20 p.c. of the countries are at risk of ecosystem collapse and about half of the global GDP depends on high-functioning ecosystems[120].

PANEL 3 – SYSTEMICALLY COUPLING RESOURCES AND PLANETARY HEALTH – THE RESOURCES PLANETARY HEALTH TOOLBOX AND SUSTAINABLE DEVELOPMENT GOALS (SDG)

The explicit interconnectedness between resources and health[29] is crucial when designing and implementing the SDG agenda (the social contract) and the maintenance of life support functions of the biosphere (the overshoot process). The underlying societal boundaries are socioecological processes embedded in social relations and institutions that

determine how goods, services, etc. are produced, distributed, and consumed[8]. We estimate that most of the 17 SDG goals (75 p.c.) have resources and health at their core (see also[46]) that inherently makes them the metrics, support, and vector of equitable and sustainable development in social, economic, political, cultural, and environmental terms. This is not surprising: individually and collectively, the 8 billion humans are concerned on a daily basis with accessing resources to sustain their health and be able to do so in the future. For example, food as nutritional process is a daily energetic need for humans (metabolic energy) at similar or higher level of concern compared to other energy needs (*e.g*., thermic energy in transportation, housing, etc). In addition, there is no substitute for food resources and their base (land and water[31]).

The acceleration of world demand for limited resources is incompatible with SDG imperatives[18]. There is compelling evidence that making green growth the building block of SDGs is misleading. A range of scenarios, including carbon budgeting, resource efficiency, incentives, and technological innovations, indicates that decoupling GDP from resource use under current growth expectations (2–3 per cent year increase) is not possible[80,127], despite efforts to reduce coupling of CO2 emissions and growth[128]. Eisenmerger *et al*. (2020) explore the SDG process in a socioecological perspective to show that the SDG targets and indicators are biassed toward economic growth (essentially resource productivity, efficiency, and intensity), fail to monitor absolute trends in resource use, and underscore ecological goals, *e.g*., SDGs rely mainly on institutions responsible for unsustainable resource use. Stated otherwise, SDGs lack coherent and systemic understanding of how socioecological processes operate. Therefore, the articulation of major global challenges and SDG implementation is unlikely to succeed. As a result, their political impact is low[129,230], reflected for example in the lack of legislative action to changing resource allocation.

To address such handicaps, we designed the Resources-Planetary Health Toolbox (RPHT). RPHT has been inspired by the conceptual reframing of humanity-nature relational representations (namely their local-global and space-time translation into actionable instruments[41] that posits socioecological systems in terms of multilayer hierarchy of variables relevant for the sustainable management of resources (*e.g*. resource system, governance system, actors, interactions, rules, outcomes). RPHT is complementary to Ostrom's Common Pool Resources framework (Table 1) to which it adds a strong societal responsibility dimension through the social health component of planetary health. Also, it can be more readily adapted to any scale from local to global, providing knowledge to modulate the rate of production and consumption systems[16,50] while engaging with long-term sustainability through rules, regulations, and norms matching the attributes of resource-to-governance systems.

PANEL 4. NEEDS AND RIGHTS: RESOURCE JUSTICE, THE FAIR ACCESS TO RESOURCES FOR ALL

The current system of resource consumption and material living standards of industrialized countries cannot be generalized. There is a paradox of needs in productionist and consumerist capitalism that consists in shaping market behavior and social attitudes. To counter this paradox, it is necessary to think in terms of institutions capable of defining, collectively and democratically, productive and non-productive choices. The choices respond to societal (*e.g*., public services, resource justice) and environmental constraints[44,46], and imply systemic nature-related risks. Those risks have to be identified, assessed, disclosed, and amortized[62], see also[37].

The essence of adjusting basic needs and resources implies considering the triptych "fundamental goods" (land, water, and wealth produced by natural resources, all of which are limited), "basic needs" (both economic and social), and "fundamental rights" (the normative obligations of human rights) (see also Table 3). The latter as expressed in particular in the Draft Optional International Protocol on Economic, Social and Cultural Rights: "civil, cultural, economic, political, and social rights are universal, interdependent, and indivisible"[131]. Therefore, resource justice becomes a pluralistic process about collective and individual relationships encompassing the distribution of rights and responsibilities on Common Pool Resources (distributive justice) and the role and ability of stakeholders to contribute to decision-making (procedural justice[7]).

Denying fair access to vital resources violates fundamental human rights and raises concerns about resource stewardship governance, with impacts on both social health and ecosystem health. While the adjustment of resources and needs is at the heart of business and family or community functioning, that concern is more discreet in public policies. Such policies need to be based on core

principles (Figure 1B) that translate into in context or specific situations. For example, food systems would be guided by second order principles, such as the primacy of food needs / food security, food democracy (*i.e.*, from fork to farm) to balance the offer-demand on criteria beyond the economic imperatives (the price signal), public governance of land-water-air resources to support agricultural systems diversity, transparency and accountability along the entire supply chain, etc.). Enacting the principles requires implementing planetary health robust metrics for accessible resources and basic needs, and assessing the adequacy of resources and needs in given settings (Figure 3; sections "Providing systemic instruments" and section "Making cost-benefit evaluations systematic – on traceability").

PANEL 5. CHINA'S ECOLOGICAL CIVILIZATION AND BELT AND ROAD INITIATIVE. REFRAMING WORLD ORDER AND GLOBAL INSTITUTIONS?

The ecological civilization[132] is a narrative about China building a great, prosperous, powerful, democratic, culturally advanced, and harmonious socialist country (made public during the 16th National Congress in 2002), and enshrined in the country's Constitution since 2018. More precisely, the ecological civilization is a program of resource- and needs-driven socioecological transformation grounded in China's experience of modernisation and considered to encapsulate traditional narratives, and social and cultural beliefs and practices rooted in the principle of "Unity of Man and Nature"[133]. The harmonious development of man, nature, and society is aiming at achieving prosperity and meaningful life. The ensuing "five-sphere integration plan", with ecology as novel priority, is supported by a framework of national plans, pilot and experimental zones, coordination of resource management, action plans for rural revitalization and land management, assessment and evaluation instruments and standards, and a central special fund for ecological civilization[88].

Conceptually, ecological civilization and planetary health appear congruent. However, the former consists so far of a rather classical elaboration of the three-pillar system of sustainable development: the economy is driving the societal and the environmental spheres. The emphasis is on factors of production, intensification, and efficiency, technological solutionism and investment-driven economic growth (*e.g.*, "pollute first, govern later"). This is offering a competitive advantage to the Chinese economic and technological sector. The framework has weaker political commitment to social justice and participation, awaiting for the consolidation of institutional, administrative, and judiciary structures in the public interest[134,135]. However, the Chinese science with its own intellectual traditions offers insights on issues such as the institutional subordination of markets[132], high tech propensity, and the deployment of the carrying capacity approach[36] in evaluating progress indicators of ecological civilization across China regions[88].

A comparative study of the Resources Planetary Health and ecological civilization methodologies would have some obvious interest and merit.

The ecological civilization can not and should not be dissociated from the State imaginary and actions around grandiose infrastructure strategies influenced by business, vested rent-oriented interests, and global power games. Thus, investment and infrastructure are used as tools with multiplying economic effects. Two examples are presented below.

The Chinese Belt and Road Initiative (BRI) is considered a defining force for the 21st century. The geostrategic program, a 125 country networking, has been designed to export China's model in developing countries mainly. What is the development paradigm behind one of the largest infrastructure development projects in history[136,137]? The social and ecological impacts of planetary proportions (for ex., extraction and imported materials for infrastructure construction and associated carbon emissions) are the starting point. The global governance consequences are clearly marking a long term resource-driven and investment-supported world order strategy. To that aim, BRI is (1) coupled to an Ecological and Environmental Cooperation Plan[135], and (2) supported by the digital remotely sensed data for BRI routes feeding the Belt and Road Science Plan, *e.g.*, the evaluation of water resource accessibility along the BRI trajectories[138]. Last but not least, there are concerns about risks associated with such a large development project, including regional tensions (such as fishing area conflicts, to name just one example), debt trap diplomacy, etc.

At the same time, China's growing participation in international organizations and global governance institutions (the Going Global strategy), meant to extend its global influence, is reflected by the presence of high ranked Chinese servants / officials within major UN, health,

banking and finance, trade and standards, and environmental institutions[139,140].

Taken together, the above considerations leave room for multiple interrogations. In the first place, on Beijing making ecological civilization the official narrative of China and considering the current level of trans-Atlantic global dominance. Also, what is meant by ecological civilization in terms of actual values and priorities at a time when China is pressingly seeking to take a separate path from the global governance system? Considering the overall importance of the ecological civilization enterprise, it is expected that the civil society at large, scientists included, will attempt taking over the asset. In doing so, how will they elaborate and labor on, and make it actionable for the common good?

Acknowledgements: This work was supported by a cooperation program between France (ENS de Lyon), Switzerland (EPFL), Norway (Oslo University) and Sweden (Karolinska Institutet) conducted between 2014 and 2020. Our thanks to François Collart Dutilleul and Fabrice Riem (CELT program, and the ERC project LASCAUX) for sharing their work on the legal aspects of resource justice through the adjustment of resources and fundamental needs approach. Ideas expressed in this paper have been elaborated through the activities of the Michel Serres Institute and seminars and projects with biology master-degree students at ENS de Lyon during 2014 to 2016 (http://institutmichelserres.ens-lyon.fr/spip.php?article359 and http:// institutmichelserres. ens-lyon.fr/spip.php?article317).

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