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Review

Global Resources and Resource Justice - Lost in Frameworks and the Way Forward

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Abstract: The lexical analysis of seminal policy-to-diplomacy documents from the socio-environmental discourse of the last fifty year agendas allowed examining the evolution of five themes: resources/waste, pollution, social and economic development, justice, and health. Contextual affinities were strongest between resources, pollution, and health and are linked to societal trends and pressures. On those grounds, the central role of resource stewardship according to nature's physical limits is highlighted, and dedicated concepts, analytical frameworks, and methodologies with different degrees of sustainability are analyzed. To reframe the identified social and economic problems, the work proposes criteria and choices that (1) allow to compare the dynamics of socioecological states across the planet, (2) help matching the pace of socioecological change by addressing path dependencies through participation and engagement of communities, and (3) enable stakeholders to make trade-offs and take decisions in specific social, economic, political, and cultural contexts. The prioritization of resource justice and responsibility becomes a societal project: from Wellfare State to commonfare communities.

Keywords: access and (re)allocarion ; data systems ; carrying capacity ; earth4all ; ecological civilization ; one health; planetary boundaries ; planetary health ; quality of life ; societal boundaries ; socioecological agendas

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Nature is our only hope… (Pisaro)

Collective inclusion into nature is percieved by human groups as a problem which they must overcome in order to exist as such (Charbonnier, 2015).

1. Introduction. Shifting Agendas - 50 Years of Socioecological Miopia

The reality of the last 50 years is that 75% of the world's population still lives in poverty, with 10% in extreme poverty. If the latter has been partly reduced, social inequalities have exploded (NASEM, 2021 ; Dyxson-Declève et al, 2022). Likewise, it is worth mentioning the contrast between the total funds allocated to the protection of biodiversity (approximately 130 million dollars per year) and the subsidies harmful to the environment (of the order of 2.5 billion dollars per year) (Narain et al, 2022). Thus, if global wealth has increased, this has been to the detriment of nature and a large part of humanity.

This is not all : the launch of government-supported organizations including financial institutions, corporates, and market service providers with over US$20 trillion in assets, called Taskforce on Nature-related Financial Disclosures framework and Science-based Targets Network pilots (https://tnfd.global/about/), has set a highway for corporate to take action on nature (TNFD, 2023). For example, green finance for conservation consists of compensation mechanisms that are permits to pollute and speculate through markets working toward the commodification of nature. Obviously, ecological priorities are not market priorities.

And yet, the report for the Club of Rome (Meadows et al, 1972) has provided decades ago a political, economic, social, and environmental questioning of the dominant economic model, starting from the issue of the finiteness of physical resources. Also, in the Stockholm Declaration (1972) the development of human societies was seen as closely dependent on nature, i.e., the inseparability of

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the social, environmental, and developmental matters. This means that economic and governance systems exert direct and indirect effects on ecosystems and, in return, the resulting externalities feedback on social and governance structures (Ostrom, 2009; Bourgeron et al, 2018). These reports have illuminated scientific and diplomatic paths such as

- the Rio Summit (1992) focused on the Millennium Development Goals, followed by the Sustainable Development Goals (SDG), but whose political effects proved weak (Biermann et al, 2022). Namely, SDG targets and indicators seem to ignore how socioecological processes operate, are biased 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 (Eisenmerger et al, 2020);
- the ecological footprint and subsequently planetary boundaries (Suppl. File1 ; Steffen et al, 2009; Whitmee et al, 2015) to quantify human pressures on the biosphere;
- societal boundaries (Suppl. File 1 ; Brand et al, 2021) to specify the frameworks in which increasingly strong social inequalities occur and how to bridge them with genuine physical boundaries (Gupta et al, 2023) or the doughnut economics approach (Raworth, 2017), and the carrying capacity modelling (Mote et al, 2020).

In order to understand how this scientific, institutional, and diplomatic dynamics evolved over the 1972-2021 period, we have

- sketched the societal and geopolitical landscape of this period (**Figure 1***)*;
- dissected the elements of language and the evolution of associated discourses deployed over the last fifty years using five structuring themes: resources/scarcity, pollution/waste, social and economic development, justice, and health (Pincemin and Negrutiu, 2023).

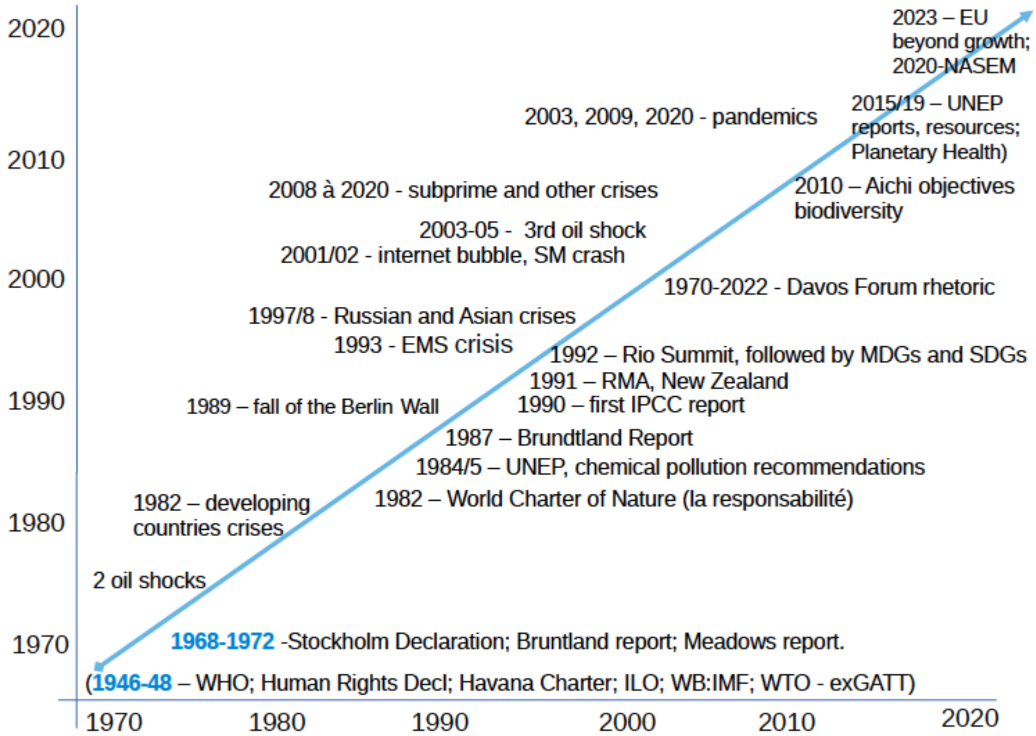

Figure 1. The diagram illustrates the geopolitical and institutional context of the last 50 years in which the analysis has spotted its lexical analysis. That reality is characterized by the time of crises (ordinate axis) which were essentially financial and energetic, and the time of institutional and diplomatic agendas and rhetorics (abscissa axis). This landscape expresses, in various forms and with varying intensity, the shared responsibility and the urgent need for appropriate measures to protect nature and its resources, at the national and international, individual and collective, private and public levels. The list of examples is not exhaustive.

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Notes and abbreviations.

WHO, World Health Organization; ILO, International Labor Organization; IMF, International Monetary Fund; WB, World Bank; WTO ex-GATT, World Trade Organization; IPCC, International Group of Climate Experts; EMS, European Monetary System, and more general awareness of the limits of free capital movements; RMA, Resource Management Act; MDGs, Millennium Development Goals; SDG, Sustainable Development Goals; SM, Stock Market; UNEP, United Nations Environment Program; NASEM, National Academies of Sciences, Engineering, and Medicine of the United States – Nobel Prize call and report on the science of sustainability.

Based on several science and/or diplomacy texts from the period 1970 – 2020 (Suppl. File2), we attempted to understand how international institutions sought responses to social, economic, and environmental crises. Our work identified the following main points):

(1)The theme of ***resources*** emerges as a primary economic and political concern for the period analyzed;

(2) The analysis of lexical contexts shows that ***resources/energy and pollution*** are systematically linked, their origin being multiple (industry, agriculture, transport);

(3) The link between ***pollution and health*** is affirmed throughout the discourses. The extraction-production-consumption-waste cycles have consequences on the health of people and environments. These consequences are all the more marked as elements of institutional discourse and policies that have become more vague and permissive (e.g., deregulation) from the 1990s on;

(4) The link between ***resources and health*** as a factor of justice and social health is expressed in a less direct way (see also Ottersen et al, 2014); however, it can be recognized in the repeated links between environment and health (impacts of a degraded environment on health);

(5) The constant concern of early texts for ***demography*** loosens its concrete dimension in more recent texts to shelter behind less politically sensitive issues (e.g., SDGs, energy efficiency, and more generally climate and well-being).

To summarize, the observed links between resources - global pollution - health constitute the backbone of a social and ecological deconstruction carrying current systemic crises (see also Fuller et al, 2022). The reasons are the lack of political coherence and the growing weight of economics and finance in political developments, but also the limits of technological solutionism and the dogma of infinite growth (Meadows et al, 2005; Dixson-Declève et al, 2022). It is the transition from discourse to its implementation which does not work, because the political will expressed during 50 years has been unable to overcome its own institutional inertia and the growing influence of unbridled economic and financial systems resulting from it (Negrutiu et al, 2023).

It was not until 2021 that the Nobels (NASEM, 2021) clearly expressed fairly radical positions, arguing that since GDP does not measure health, one can no longer ignore the increasingly marked relationships between global pollution and health. They were seeking to define priorities:

- The commons, already highlighted in Brundtland (1987) and reaffirmed in the US National Academies debates (NASEM 2021b; 2023a), remain the institutional horizon to reach, AND
- Planetary health (Suppl. File1) emerged as one of the key ideas, further confirmed through the joint program of the American and Chinese Academies (NASEM, 2023b).

In the same vein, the Global Alliance on Health and Pollution and the derived Lancet Commission on Pollution and Health (associating UN institutions, NGOs, the World Bank, the EU, academia, and Ministries of Health in several developing countries) advocate for resources and solutions to soil, water, air, and other types of pollution problems and associated health consequences (Fuller et al, 2022).

2. The Global Resources

Main agendas concentrate nowadays on climate change, biodiversity, energy, or water use. As shown in the previous chapter, the resources problematic as a whole revealed itself as a historical denominator. Resources are the nutrients of social ecosystems (Sverdrup et Ragnarsdottir, 2014) and stand therefore as a prerequisite of sustainable societies. However, humans wrongly frame resources.

What follows is a brief argumentation and contextualization of the current resource landscape (Suppl. File 3).

The notion of resource is a social construction, a political concept, and a mode of production - it is technology, law, culture which define what is or can be a resource. The mobilized resource base is constantly the subject of debates, negotiations, and choices. Their perception by societies is constantly evolving (Arrow et al, 2004). The political assertion that human societies can free themselves without limits of material constraints in a world with finite resources is a very problematic gamble.

The perception of this finitude has led to considering resources in terms of stock and measurable stock. To set up a metric, it was necessary to distinguish resources, a subjective and controversial notion, and reserves, a category objectified by the criteria of extraction, production, and marketing, sometimes manipulated by strategic communication. But these figures would only be meaningful if they could be compared with an assessment of needs (Negrutiu and Salles, 2013). However, the ratios which divide the identified reserves by the consumption of the current year have no other meaning than to know whether the actors manage to control the stocks or must invest in the discovery or development of new reserves. Hence ill-informed debates about resource scarcity. Price variations are indicators of supply - demand imbalances, and act as levers for investments.

Economics of resource scarcity. Freibauer et al (2011) define scarcity as a combination of observed shortage of natural resources, a perceived dependency on natural resources, and the fear of their global depletion (also see Neumayer, 2000). They analyzed the synergistic effects between and within "old scarcities" (fertile land, fresh water, energy, phosphorus) and "new scarcities" (environmental degradation, loss of biodiversity, or transition time). The political, social, organizational, institutional, and economic determinants of scarcity raise concerns about the future availability, accessibility, utility value, and distribution of resources (also see Kemp and Owen, 2023). For example, resource scarcity generating institutions create profitable shortages and overexploitation of resources leading to impared freedom, social inequality, and environmental degradation (see also De Schutter, 2017).

Importantly, this apparent disorder is likely to have his roots in the maldistribution of rents from natural resources and the effective supremacy and protection of exclusive property rights (material and immaterial), together with the absence of an international competition law (Collart Dutilleul, 2021). By extension, this highlights the asymmetry between the dominant market rules (supply and demand) and the necessary adequacy between the vital resource needs of populations and the maintenance of the life-support capacity of natural environments on which societies depend. That asymmetry further reflects the ongoing process of ecological colonization driven by developed countries (Hickel et al, 2022).

Resource governance. The resource problematics are largely restricted to economic and market logic, natural resources being merely considered as fluxes of values and exploited with no consideration of environmental or social costs (Negrutiu, 2022). The demographic and market pressures, and the global natural resources “rush” have led to chronic socio-ecosystemic deficits or debts, with food-health-environment-poverty imbalances (real-time simulations available at http://www.worldometers.info/). The examples below tend to illustrate the efforts deployed by certain institutions or organizations to tackle some of the main difficulties or bottlenecks.

(1) The New Zealand Resource Management Act (RMA, New Zealand Parliament, 1991 and 2023) is a 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. It illustrates how an integrated resource governance can serve as an overarching principle spanning the national interest.

(2) The International Resource Panel (IRP), UNEP. The Panel is an independent group of scientific experts established in 2007 by the UN under the auspices of UNEP to help countries use natural resources without compromising present and future human needs. The Panel's specific mission is to contribute to assessing environmental impacts across the entire life cycle through a better understanding of how to decouple economic growth from environmental degradation. The

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IRP reports express, year after year, the pragmatic vision and exhaustive expertise the Panel has developed (UNEP, 2019), with no or insignificant effect on business as usual.

(3) The Natural Resources Governance Framework, an initiative of the International Union for the Conservation of Nature, has provided a "set of principles, standards, and tools for assessing natural resource governance and promoting its improvement" (IUCN, 2019) through transparency, liability, controllability, responsibility, and responsiveness.

There is little if any cross talk between such institutional achievements and there is no agreed upon assessment methodologies and instruments. To that end Fairbrass et al (2020) have proposed a guide for natural capital assessment. The Natural Capital Indicator Framework organizes a large number of variables into a set of key and headline indicators based on the Four-Capital model of wealth creation (e.g., natural capital stocks of ecosystem and commodity assets, ecosystem flows from natural capital, human inputs and outputs in the form of benefits and residuals).

Open questions. The following could highlight some of the pending issues :

- The opposition between exhaustible and renewable resources (biotic or abiotic) remains structuring. The exploitation of the former must be reasoned in relation to the substitutes imagined, while the potential of biological resources is conditioned by the management of their stocks.
- Ultimately, can societies live on a base of exclusively renewable resources? The challenge is enormous, because the quantitative ratio of exhaustible/renewable resources raises questions about the capacity of exclusive renewable energy options to offer a choice other than voluntary sobriety as a way of life (Neumayer, 2000). Therefore, the inegrated management of resources, in particular water and energy resources, becomes the challenging issue for ecological sustainability, equitable technological progress, and social welfare (Ramirez-Marquez et al, 2024).
- The unequal distribution of resources, in quantity and quality, is at the origin of rents which have ambiguous relationships with economic development and remain a source of tension and geo-political conflict (Gabriel-Oihamburu et al, 2012; Gylfason, 2011). Thus, history shows examples of resource mobilization in which the abundance of resources translated into less development in the better-endowed countries. The explanations provided focus largely on the political economy. Colonial and post-colonial strategies of global economy domination generated skewed relationships between stakeholders to the detriment of local communities and with pernicious environmental consequences (Umejesi, 2023). We expect these unjust and unsafe resource policies to operate in the same way on biological resources. Who owns nature has become the last political and economic boundary.
- The maldistribution of rents from natural resources is grounded in institutions and political economy despite the fact that in most national constitutions natural resources are common property resources. The supreme status of human rights in international law grants people equal and non-discriminatory access to common property resources (Wenar, 2008 ; Mahon, 2008 ; Gylfason, 2018). In addition, the right to an adequate standard of living provides leverage to the imperative redistribution of incomes and resources within societies (Hickel, 2019).
- What levels of accessible resources need to be fairly allocated in the coming two decades (Dixson-Declève et al, 2020; Hickel et al, 2019) while maintaining the life support capacity of the Earth system ?

Reframing social and economic problems according to nature's physical limits linked to social trends and presures make the object of the next chapter.

3. Boundary Approaches in socioecosystemic Context – Coupled Human-Natural Systems

Planetary Boundaries. The concept (Suppl. File1) has been widely adopted by UN and other international and national bodies, agendas, and scholars. It is about the Earth's buffering capacity endangered by human activities that affect primarily the biosphere, namely the Critical Zone, i.e., the intersect of atmosphere, hydrosphere, litosphere, and the living (Suppl. File1). They constitute the self-regulating functions and cycles of the biosphere, those on which the ecosystem services so much depend on.

The buffering capacity, when investigated through planetary boundaries, consists of a system of thesholds or tipping points defining safe versus risk range values (updated by Rockstrom et al, 2023). Several of the global scale boundaries have presently been transgressed.

As for the merits of the planetary boundary approach, one can put forward the better understanding of the Earth system and safeguarding the global commons. Conversely, boundary values remain controversial for land use change or fresh water variables, as do the quantification of biodiversity loss, functional biosphere integrity, and global pollution (https://en.wikipedia.org/wiki/Planetary_boundaries). Furthermore, concerns have been raised about using such boundaries in isolation. Also, the issue of whether the economic and political control and management through thresholds would be meaningful. For example, land use change boundary alone would not take into account soil degradation and soil loss processes. The necessity of including a tenth boundary, the net primary production as the measure of accesible biomass, has been proposed (Running, 2012). Last but not least, the area of planetary boundaries has been viewed as an evolving concept to be used with precaution, while social sciences have challenged the unidirectional thinking of the approach (Brand et al, 2021) arguing for the need to elaborate not only a safe but also a just Earth system.

Two of the above limitations require some additional consideration.

(1) Compiling interactions and connections between boundaries is essential. It would allow, for instance, interlinking pollution and water resource degradation, or the nexus between land use change, water boundary, and biomass production. In this sense, our analysis has showed that individual boundaries can be aggregated into two major pressure subsystems of the biosphere, namely food systems and global physico-chemical pollution (Arguello and Negrutiu, 2019 ; see also Campbell et al, 2017). In this acception, the soil-water-biomass system is conceived as a major primary resource matrix (Negrutiu et al, 2020).

This clarification can radically change the way tools for alternative environmental evaluation are developed to inform resource policies and decision-making with broad poverty, health, and economic development implications. For example, when addressing energy transition concerns (Millward-Hopkins et al, 2020 ; Rammelt et al, 2022), food security as metabolic energy stands out as the most urgent energy transition issue for most of humanity.

(2) Plantary Boundaries integrate nowadays some of the just Earth system boundaries, by considering three justice criteria for a safe space for humanity, namely interspecies, intra- and inter-generational justice (Rockstrom et al, 2023).

Taken together, the ensuing social dimensions are finally understood as a societal boundary system that integrates social justice for resources and services linked with planetary limits constraints.

Societal boundaries. Earth system justice is meant to allow living within biophysical boundaries in ways that enable a fair access to essential and interrelated needs and services (Millward-Hopkins et al, 2020). A just access to material resources concentrates on universal needs, such as food, water, energy, and infrastructures (e.g., housing, transport). This is based on international human rights principles extending to procedural and substantive (i.e., distributive, corrective, and restorative justice ; Gupta et al, 2023) consisting of principles of equal distribution, meeting minimal needs for all, and limiting excess resource use. They are likely to aleviate the unequal impacts of pollution, epidemics, or acces to land, but also to adress responsibilities for environmental degradation and disparities between countries, communities, and social and racial groups (Hickel et al, 2022).

The operationalization of the Earth justice framework targets access and allocation means, such as (1) access to information in decision-making, to civic space and legal remedies, minimum resources and services, AND (2) Allocation of risks and harms, as well as of responsibilities for access and risks. For example, access indicators have been established to quantify key material needs for food, water, energy, and infrastructure at two levels : escape from poverty and enabling a dignified life (Rammelt et al, 2022). Once evaluated, the minimum needs are integrated with the current levels of consumption figures and converted to pressure levels per capita and per global Earth system. Stewart-Koster et al (2024) have specifically evaluated the basic access to water within the safe and just Earth system . This has been done based on eight groups of river basins across the world according to a range of access levels and as function of available surface and ground water. This is one way to assess the (in)adequacy of needs versus resources required in the Earth system for the preservation of life-support capacities of ecosystems.

It is worth noting that societal boundaries have additional dimensions that embrace contrasting behavioural aspects, such as trust, immoderation, prestige. Since human needs expand with knowledge, technology, and material richness

- freedom has largely been built on the abundance of resources, a colonial and industrial era lasting imprint that persists under a variety of geopolitical strategies (Charbonnier, 2020 ; Umejesi, 2023) ;
- the essence of power systems relies on the multidimensional logic of unbridled rush and competition on resources, the mantra of productivity and concentration (i. e., low cost nature and labor ; Moore, 2015).

In summary, societal boundaries can become instrumental in promoting societal self-limitation with specifications debated according to sociocultural determinants implying institutional reframing of how goods, services, etc., are produced, distributed, and consumed (Brand et al, 2021). Stated otherwise, the knowledge and actionable capacity of designing economies as social projects at the junction between nature and societies are gaining ground. On these lines, **Table 1** is a synthesis of additional and complementary contributions to the field, including the Club of Rome report 2022, the Carrying Capacity (HANDY model), Beyond GDP (Gumbo model and Quality of Life), the Ecological Civilization, and Resources-Planetary Health frameworks.

Table 1. Contrasting and complementary concepts and methods, aiming at internalizing social and ecological costs. The analyzed frameworks emphasize different aspects of alternatives to business as Usual.

Methodology and Refs	Ecosystem condition	Social condition	Observations
Safe & just Earth system (PB & SB) Rockström et al, 2023; Rammelt et al, 2022; Gupta et al, 2023.	Planetary boundaries, a 10 (11) tipping points system: biosphere functional integrity, natural ecosystem area, surface and ground water, nitrogen and phosphorus, aerosols, ocean acidification, climate, (biomass). Defines risks levels.	Access and allocation levels of minimal needs, such as food/nutrition, hygiene and water, energy, housing, transport. Next: living conditions, healthcare, education.	Prescriptive, from global to national scales. Some countries develop PB approach to assess natural capital states. Possible extension of SB to non-material needs.
Earth for all 2022 (Club of Rome) Dixson-Declève et al, 2022. See also Suppl File 4.	Energy, crop, and food sectors production. Effects of human economy on climate, nutrients, forests, and biodiversity acording to planetary boundaries.	Sectors: wellbeing, population, output-consumption, public, labor market, demand, finance, reform delay, inequality and social tensions.	Non-prescriptive. 11 synthetic parameters (>100 variables and 80 fixed parameters, including feedback effects).
Carrying capacity (HANDY model, offering a single end-indicator combining several factors and variables) Mote et al, 2020.	Earth system variables: nature capacity with regeneration and depletion rates and leves (non-renewable stocks, regenerating stocks, renewable flows). Associated to sink processes, considered as ecosystem services. Projected variables: atmosphere and chemistry, land, ocean and sea ice, aerosols, carbon cycle, vegetation dynamics.	Human system variables (levels, rates of change, distributional inequality) - fertility, mortality, migration, heanlth, GDP/capita, material and energy per capita, waste and emissions per capita, etc. Projected variables: demographics, water use, agriculture, energy, industry, construction, transportation, trade.	Non-prescriptive. A minimal model with bidirectionally interacting variables not tested so far in real life contexts. Indicators of progress: 1. Reduce per capita consumption and pollution; 2. Stabilize the population; 3. Reduce inequality in resource consumption and the production of waste, emissions and pollution.

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Beyond GDP (GUMBO model) Boumans et al, 2002; Costanza et al, 2007.	Ecosystem services assessment, conversion to monetary values. Ecosystem services subdivided into seven main types and ecosystem goods into four main types. Simulate carbon, water, and nutrient fluxes. Virtual prices for each service. Includes variations of policy settings concerning the rates of investment across natural, social, human, and built capital.	Quality of Life indicators for human needs, such as identity, freedom, subsistence, reproduction and care, security, understanding and participation, spirituality and creativity.	Non-prescriptive. 930 variables, 1715 parameters in a global model integrating dynamic feedbacks between technologies, economy, well-being, and ecosystem goods and services within a dynamic Earth system. Local to global, individual to collective, targetting the common good sector.
Eco-civilization (carring capacity equiv.) Ouyang et al, 2020; Zuo et al, 2021; Mior et al, 2022.	Gross ecological Product (GEP), a measure of the aggregate monetary value of ecosystem-related goods and services flows in a given region in an accounting period.(Market and non-market prices, value of marginal product and proxies using measures of avoided or replacement costs). Alternative approach: resources (water, forest cover, ..), environmental pressure (pollution), and environmental governance.	Social life and public services (population growth and density, physicians and medical beds, rural and urban housing, public transportation and road area, park area, public libraries, college student figures).	Non-prescriptive. Regional analyses. Spatially explicit integrated ecological– economic modeling that predicts the flow of ecosystem services, and economic valuation.
R***esources-Planetary Health*** Integrates ecosystem, social, and people's health (carring capacity equiv.; dynamic dashboard of interactions, interdependencies between variables). Arguello et al, 2022; Negrutiu et al, 2023.	The state of the ecosystem capital: core accounts for land use change, water and rivers, biocarbone, and ecosystem infrastructure. Territorial potential for biophysical entities measured as Ecological value. Four core accounts are integrated, with intensity of use and health index as common denominator, and proxies for ecosystem services and biodiversity. An instrument to understand territorial trends, identify degradation risks, and the impact of public policies and economic activities on the ecological potential.	Public health core indicators and universal health coverage; Equitable access and allocation of resources for all. Universal social protection (education, health, shelter, employment, revenue, …). The place of the market in political and financial decisions, the promotion of the commons and ecological programming in public policies.	Non-prescriptive. Local to global. Annual accounting period. Experimental transposition of the UN system of Environmental Accounting adopted by the UN Statistical Commission in 2021. As complement to current national accounting system. Objective for stakeholders: no net social and ecological degradation.

Note: Non-prescriptive assessment instruments enable tracing socioecological trajectories in the context of unpredictable effects of cumulative shocks, such as pandemics, climate and associated crises, technological social impacts, societal trust and acceptance, ….

4. Socioecosystems as Carrying Capacity, a Debt and Inclusive Health Repair System

The accellerating degradation of socioecosystems during the past decades means acknowledging the existence of unpaid costs corresponding to socioecological debts (Weber, 2018). The accumulation of such debts over time remains virtual as long as they are not measured and recorded in balance-sheets in order to be offset so as to anticipate and avoid economic and political risks.

The debt-cost thinking can be translated into a health state assessment of socioecological situations undergoing degradation (or improvement). For example, the current Planetary Boundary states and risk scales represent, as a matter of fact, a giant health bubble, from individuals to societies and the planet at the same time (Suppl. File1 ; Negrutiu et al, 2023). The extension of the notion of health to the social aspects is also a way of thinking the economic health. It would make it possible to strengthen a set of legislative and political potentialities, e.g., instruments for developing the commons and for assessing real social and ecological costs.

In attempting the current debt-cost-health reframing, one has to dive in the current inclusive health landscape. It consists of frameworks known as One Health, Ecohealth, Planetary Health, or Global Health (Suppl. File1). One Health and Planetary Health stand out as two competing programs in science, economy, and policy areas developed in the last decade.

Both One Health and Planetary Health present themselves as holistic and systems-based approaches, allign with SDGs and climate agendas, and ambition integrating policy, legislation, finance, sectoral activities and institutions, and coordinating capacity building, knowledge, and data spheres.

The main dimension that is apparently lacking or at least is not directly addressed is the social health *per se* (Suppl. File1, the integrated systemic health).

To deal with the above caleidoscopic picture, the synoptic ***Table 1*** indicates that the analyzed approaches offer alternatives, substitutes or complements to GDP. Is there a unifying principle across the growing socioecosystemic family? Carrying Capacity (Suppl. File1; Mote et al, 2020) is very likely the concept that best reflects the necessity to integrate nature and human systems and to maximize socioecological outcomes. Carrying capacity is human economy within and with nature. In this sense, the analyzed frameworks illustrate different levels of sustainability modelization capacity, risk boundary assessment, variable interdependences or feedbacks, and operationalization.

For example, the physical dimensions of carrying capacity is addressed through Planetary Boundaries, Earth system models, environmental (e)valuations (Suppl. File 3), Gross Ecosystem Product, global resources. The social aspects of carrying capacity includes dashboards of fair access and allocation of material and other needs, quality of life indicators, social life and services indicators, and the market versus the commons instruments.

5. Future directions – Natural Resources Stewardship to Meet People's Basic Needs and Maintaining Life-Sustaining Capacity of Natural Systems

The reported landscape of competing concepts, instruments, and variables has led to a heterogeneity that generates confusion. For example, environmental evaluation methodologies (Weber, 2018) in use operate via (1) Pressure based indicators (reference value or limits, e.g., planetary boundaries and quotas), (2) Ecosystem services assessment and valuation (albeit confronted with the limits of monetary valuation), and (3) Ecosystem maintenance (systemic) approaches that evaluate ecosystem health and degradation costs that can translate in compensation versus restoration strategies. In the spirit of the present analysis, choices should be dictated by the respective capacity of such methodologies to inform the common interest, while implementing good practices in public policies and economic activities (see also Ostrom, 2007). For example, making food systems and forestry practices become regenerative, nature positive has become at present an absolute priority in a just transition process (Negrutiu, 2022; see also Ramiez-Marquez et al, 2024).

Making methodological choices is important for an additional reason, namely enabling performing simultaneous comparative evaluations of socioecological states and dynamics across the planet at different geographical scales. For that purpose, the following can constitute the matrix of future developments:

(1) Global resources stewardship becomes the common denominator in assessing human activities and institutional systems. Priorities should be set on Central Zone resources, namely soil, water, and biomass, combined with collectively making decisions on resource extraction and waste emissions. Defining in context extraction and consumption caps is likely to become the norm.

(2) Considering current Earth system limits and the state of economic and social matters, revisiting wealth allocation/redistribution mechanisms from market to State levels should be the first

step in defining a safe and just Earth system. The consequence will be a substantial transformation of business as usual.

(3) In the light of the above objectives, research work and science-to-policy developments (cf. ***Table 1***) should focus on

- The Earth for All protocol, designed for global, regional, and national trends modeling (also see Suppl. File 4). Free availability of the Earth for All game, with a user-friendly interface, would allow running the model by various actors and scholars with highly profitable methodological benefits.
- The Resources-Planetary Health toolbox, designed to assess ecological, social, and public health indicators and to model interactions among them, enables local to national scale annual reporting and integration into national accounts. The tool can be enriched by the Just Earth system protocol (e.g., Rammelt et al, 2022). For local resource sectors or categories, the Ostrom approach (Ostrom, 2009) – at the crossroad of institutional management and community-based natural resource stewardship – is taylored for collective responsibility, enforcement of social norms and institutions, and conflict prevention or mitigation in areas as diverse as land use and tenure systems governance, food security, or fair access to water and forest services.

Deploying the full potential of the above proposed methodologies requires careful consideration and political commitment to reframing the big data landscape. A great deal of data resources are currently not Feasible, Accessible, Interoperable, and Reproducible (FAIR system; Wilkinson et al, 2016; Fairbrass et al, 2020; Arguello et al, 2022; Ramirez-Marquez et al, 2024). Coordination of international bodies and national public policies on data systems

and dedicated platforms is still far from reality. If it were, its implementation would allow working out meaningful and coherent standards and taxes, rules and good practices of investment, full cost of products and activities and thus the amortization of unpaid socioecological capital (e.g., financing of restoration and conservation of nature, payment for ecosystem services), covering ecological and financial risks, effective conditionality of public contracts, and much more.

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