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From planetary to societal boundaries: an argument for collectively defined self-limitation

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ABSTRACT

The planetary boundaries concept has profoundly changed the vocabulary and representation of global environmental issues. We bring a critical social science perspective to this framework through the notion of *societal boundaries* and aim to provide a more nuanced understanding of the social nature of thresholds. We start by highlighting the strengths and weaknesses of planetary boundaries from a social science perspective. We then focus on capitalist societies as a heuristic for discussing the expansionary dynamics, power relations, and lock-ins of modern societies that impel highly unsustainable societal relations with nature. While formulating societal boundaries implies a controversial process – based on normative judgments, ethical concerns, and socio-political struggles – it has the potential to offer guidelines for a just, social-ecological transformation. Collective autonomy and the politics of self-limitation are key elements of societal boundaries and are linked to important proposals and pluriverse experiences to integrate well-being and boundaries. The role of the state and propositions for radical alternative approaches to well-being have particular importance. We conclude with reflections on social freedom, defined as the right *not* to live at others' expense. Toward the aim of defining boundaries through transdisciplinary and democratic processes, we seek to open a dialogue on these issues.

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Introduction

Over ten years ago, Johan Rockström and colleagues published a seminal work on nine "planetary boundaries," which rapidly became a crucial reference in the sustainability literature (Rockström et al. 2009a, 2009b). Alongside the narrative of the Great Acceleration (Steffen et al. 2004) and the concept of the Anthropocene (Crutzen and Stoermer 2000), the concept of planetary boundaries changed the scientific, as well as the popular, vocabulary on environmental issues. Rockström et al. (2009b) ended the longer version of their article with a call for additional work that would "focus on the societal dynamics that have led to the current situation" of transgressed or nearly transgressed boundaries; research that could propose "ways in which our societies can stay within these boundaries." Reflecting on these dynamics, Steffen et al. (2015, 8)

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argue that the planetary boundaries framework does not "take into account the deeper issues of equity and causation. The current levels of the boundary processes, and the transgressions of boundaries that have already occurred, are unevenly caused by different human societies and different social groups." Indeed, in the planetary boundaries framework, causation of transgressing boundaries is based on an Earth-systems perspective which does not allow for full consideration of the societal drivers of the ecological crisis (Chakrabarty 2018).

In this article, we maintain that a social sciences approach to the issue of thresholds and boundaries is necessary, both to avoid a reductionist conception of humanity as a de-socialized and de-historicized totality (Gómez-Barris 2019), and also to more fully understand the relation between social action and ecological destruction (Malm and Hornborg 2014; Lövbrand et al. 2015; Swyngedouw and Ernstson 2018). We began with a discussion on the planetary boundaries concept at a workshop of the Fourth International Degrowth Conference in Leipzig (2014) and this conversation was taken up again at the Degrowth Conferences in Budapest (2016) and in Malmö (2018), where the writing process began, and in Vienna (2020). It includes different voices, opinions, and experiences across (inter)disciplinary boundaries – sociology, philosophy, political science, ecological economics, and environmental studies, among others – from different regions of the world.

Where Rockström et al. (2009b) argue that "(t)he thresholds in key Earth System processes exist irrespective of peoples' preferences, values, or compromises based on political and socioeconomic feasibility, such as expectations of technological breakthroughs and fluctuations in economic growth," we claim that critical social science is essential for going beyond the *diagnosis* of the transgression of planetary boundaries to better *explain* the societal reasons for the accelerated "human-induced environmental change" that Rockström and colleagues reveal. Our argument is threefold. First, we show how the rather technocratic understanding of societal dynamics and societal relations to nature of the planetary boundaries framework is flawed in grasping socioeconomic drivers, processes, and structures causing the ecological crisis.

Second, we focus on capitalist societies as a heuristic for discussing historical structural conditions, institutions, actors, and power relations that drive the ever-expanding material and energy flows required in their societal reproduction – that is their *societal metabolism.* Here we frame specific capitalist, fossil-fuel based and industrialist societal relations to nature (Haberl et al. 2019; Görg et al. 2020; Becker, Hummel, and Jahn 2011).[1]

Finally, we introduce the alternative notion of *societal boundaries*, or collectively defined thresholds, that societies establish as self-limitations and conditions for a "good life *for all*." Societal boundaries imply a contested and controversial process and are based on normative judgements, ethical concerns, and sociopolitical struggles. They have the potential to act as guidelines for a just, social-ecological transformation through the development of collective autonomy or, in other words, "*self-limitation*" (Gorz 1989). Here autonomy implies the liberation from the heteronomous, pervasive logic of unfettered expansion and acceleration that characterizes modern, capitalistic societies, and it offers the possibility of collectively and democratically establishing rules that ensure social freedom and the conditions for a collective good life (Gorz 1980; Castoriadis 2010).[2] Within societal boundaries and through collective self-limitation, the conditions to live a good life neither come at the expense of others' ability to do the same, nor of the flourishing of future generations or nonhuman others (Kallis 2019; Fuchs, Sahakian, et al. 2021; Brand and Wissen 2021). We argue that the process of defining boundaries should involve social dialogue and political negotiations with diverse scientific and non-scientific actors, with the inclusion of different knowledge systems (Jahn, Bergmann, and Keil 2012; Tengö et al. 2017). Only through a deep democratic process can self-limitation acquire societal legitimacy.[3] With this article, we seek to open a dialogue on these issues.

The article is structured into four parts. The next section focuses on the conceptualization of planetary boundaries introduced by Rockström et al. (2009a, 2009b), critically examining the theoretical assumptions of the idea. We highlight the strengths of the approach from a critical social science perspective, while identifying key weaknesses and raising questions about the choices of boundaries selected and their thresholds, and about how these choices may mask issues of power and inequality. The third section then proposes a conceptual framework that examines the dynamics and lock-ins of modern societies by focusing on their capitalist growth imperatives. Considering "lock-ins" opens the possibility for a more nuanced understanding of the societal drivers and causes of crossing planetary boundaries and for adequate countermeasures, as well as for a dialogue between environmentally engaged research in the natural and social sciences and in the humanities. In the fourth section, we introduce the concept of societal boundaries as an alternative to current technocratic and incremental governance efforts of social-ecological transformations, and note the role boundaries and

implemented thresholds can play in the configuration of radical alternatives. We argue that *societal* boundaries are required and suggest how they can be established democratically as a social process of self-limitation that opens a space to ensure a good life for all. We conclude by interweaving the threads of these arguments and offering final thoughts on the idea of freedom in relation to societal boundaries.

Ten years of planetary boundaries: a critical retrospective

The concept of planetary boundaries was introduced by Johan Rockström and colleagues in 2009 in the wake of the United Nations Climate Change Conference in Copenhagen where countries endeavored – but ultimately failed – to agree upon a new framework for climate-change mitigation. In this context, the planetary boundaries conception was proposed. In contrast to earlier debates on environmental limits, it focused less on the exhaustion of natural resources than on the biophysical impacts of resource use and material consumption: the overfertilization of soils, the destruction of ecosystems, and the overtaxing of the capacity of sinks to absorb emissions and other effluents produced by human activities.

With the introduction of the planetary boundaries' framework, Rockström et al. (2009a, 472) delineate "the safe operating space for humanity," which lies firmly within the Holocene state. The authors argue, "The evidence so far suggests that, as long as the thresholds are not crossed, humanity has the freedom to pursue long-term social and economic development" (Rockström et al. 2009a, 475). For each threshold, the authors proposed a quantitative "control variable" (Rockström et al. 2009a, 472, 473), that is, a universal, robust indicator of system change and for which reliable data exist. A boundary exists then at a distance from a presumed trigger value of the control variable, which may encourage less attention to thresholds that are sufficiently remote and do not require immediate attention (Cohen 2021). The planetary boundaries framework underscores how non-linear dynamics characterize Earth-system changes and key processes (e.g., global biogeochemical cycles).

The concept rests on ideas, hypotheses, and insights from empirical studies in the Earth sciences, ecological economics, and theories of complex systems resilience. Based on this theoretical foundation, the biosphere is understood and analyzed in terms of its biogeochemical cycles and self-regulating ecological systems, its physical circulation systems, and its biophysical features. The concept builds on resilience thinking (Holling 1973; Berkes, Colding, and Folke 2003) and focuses on determining thresholds in the so-called Earth system where non-linear, often abrupt dynamics are set in motion that cause the planet to depart from what is called the "safe operating space" (Rockström et al. 2009a). Although sometimes difficult to identify exactly – due to incomplete scientific understanding of the complex feedbacks in the Earth system, among other factors – the planetary boundaries concept aims to map the safe operating space based on an appreciation of these thresholds in non-linear system dynamics of the Earth system (Steffen et al. 2015). Boundaries are, as the authors point out, normative judgements for the Earth system in general. Given risks and uncertainties, the authors quantify planetary boundaries by taking a risk-averse and conservative approach (Rockström et al. 2009a, 473).

Rockström and colleagues are careful to avoid the technocratic hubris of prescribing a level and composition of societal metabolism for humanity. They argue, rightly, that boundaries have to be conceptualized or defined based on the risk tolerance of societies to non-linear and potentially catastrophic change. Rockström et al. (2009b) state that the "predominant paradigm of social and economic development remains largely oblivious to the risk of human-induced environmental disasters at continental to planetary scales" (p. 32). And yet, given that the "safe operating space" identified for the Earth system can also be viewed as part of our planetary commons with implications for all life forms, this notion further requires considering its political implications. While Rockström et al. acknowledge the normative and ultimately political nature of the boundaries concept, it is not further discussed. Economic activity is identified as a key driver of anthropogenic environmental change that can push "coupled human-environmental systems" beyond thresholds of known stability and into zones of non-linear and potentially "catastrophic" environmental change (Rockström et al. 2009b), but is also not sufficiently problematized. A recent paper suggests that the boundaries concept should include consideration for a "just" as well as a "safe" operating space (Rockström, et al. 2021), yet it stops short of grappling with the complexities of different forms of justice – not solely distributional, but also procedural – and the political implications of such an approach.

Strengths of the planetary boundaries framework

The introduction of the planetary boundaries framework was a conscious intervention in environmental sciences and policy circles that aimed at nothing less

than proposing a "new approach to defining biophysical preconditions for human development" (Rockström et al. 2009a, 474). We identify three main strengths of the framework with regard to its potential contributions to transformative knowledge. First, it has widened the political and academic debate on the ecological crisis beyond climate change, which has dominated much of sustainability discussions since the turn of the century, to a more varied account of ecological and biogeochemical forces induced by societal metabolism, including topics such as biodiversity loss and eutrophication. Planetary boundaries proponents warn that the complexity of, and interlinkages among, different biophysical subsystems or processes are of utmost importance, and that if tipping points are reached, the resulting changes may be unpredictable and possibly irreversible.

As a second strength, the framework rests on the ontological claim that contemporary human societies have become dependent for their flourishing on the "stable environmental conditions" – i.e., ecological and geological conditions – of the Holocene and that there are identifiable thresholds within which this stability is secured. Framing ecological questions in this way stresses the deep connections between geology and biology, as well as human and environmental history (Chakrabarty 2020). It has provoked scholars from the humanities and social sciences to analyze particular socio-historical interconnections between human and nonhuman agents (as in the early colonial plantations) in a critical dialogue with the natural sciences (Haraway and Tsing 2019).

The planetary boundaries concept also represents a considerable refinement over previous approaches to defining ecological limits, such as carrying capacity (e.g., Daily and Ehrlich 1992) or the assessment of "overshoot" with the ecological footprint (Wackernagel and Rees 1997). Carrying capacity is a concept in population ecology aiming to determine the maximum population that can be sustained by the resources available in an ecosystem, without accounting for the role of social structure; for example, that not all populations have access to the same resources, nor are responsible for the same negative impacts (Haberl and Erb 2017). As an aggregate indicator, the ecological footprint addressed some of the shortcomings of the carrying capacity concept by reflecting technological changes in resource extraction and use (Wackernagel et al. 2004), yet stopped short of providing levels of perturbation in relation to life in the Holocene.

A third strength lies in the iconic image used to depict planetary boundaries: an infographic with Earth overlaid by concentric orbits representing three spaces as distances from a center, a safe green zone, a yellow zone of risk, and an outermost red zone of thresholds crossed. The boundaries for the nine key Earth-system processes identified in the framework are presented as dimensions emanating from the center in a simple and intuitive representation of boundary transgression.[4] The popular success of the planetary boundaries concept can certainly be attributed to the visual power of this illustration that rapidly became standard fare in scientific and educational presentations. From the World Economic Forum in Davos to students striking for climate protection, the iconic infographic has been adopted as a metonym for unsustainability and ecological catastrophe. It offers a powerful narrative for the limits of business-as-usual in terms of growth and development. In addition, the boundaries concept has given rise to the charge that we must "start living within planetary boundaries" as pronounced by the youth activist Greta Thunberg (2019). Thus, the notion of planetary boundaries went beyond the mere presentation of scientific results to change the frame of popular debates and to inform subsequent research on sustainability issues.[5] However, the diagram is a simplification – while easy to communicate, it suppresses the complexity of different planetary processes as well as their interlinkages.

Weaknesses of the planetary boundaries framework

We also see weaknesses and ambiguities that allow for "business-as-usual" and "pro-status quo" interpretations of the framework.[6] The planetary boundaries concept identified the "predominant paradigm of social and economic development" (Rockström et al. 2009b) as the main driver toward "continental and global" environmental disasters, without explaining which societal, political, and economic conditions lead to unsustainability, and in what way. It is not economic activities in the abstract that lead to ecological crisis but rather economic activities with particular logics and under certain circumstances. More precisely, we argue that the growth imperative of capitalist economies, as well as other particular characteristics detailed below, are the main drivers of the ecological crisis and exacerbated trends already underway (see next section). Indeed, even before capitalist growth economies, the enclosures of the natural commons – land, water, biodiversity and creative human labor – as part of transitions from feudalism through to militarized mercantile capitalist conquests and settler colonialism, inscribed global accumulation with a destructive logic for our planetary ecology.

Further, the planetary boundaries framework can support interpretations that do not solely emphasize technocratic operational approaches and costs, but also assume that these alone can be the solution. The technocratic bias embedded in the proposed political solutions that often accompanies planetary boundaries research ranges from including nuclear energy as a replacement for fossil fuels to the deployment of large-scale geoengineering technologies (Surprise 2018; Markusson, McLaren, and Tyfield 2018). This technocratic drift is not incidental, but rather is built into the planetary boundaries framework itself, in its view of the Earth from an "astronaut's eye view" that can only be provided by scientists, but which runs a risk of ignoring severe regional or local impacts of global warming triggered long before global thresholds are crossed (Sachs 1999; Neyrat 2016; Biermann and Kim 2020, 502–3). From this perspective, Earth is envisioned as a globe that appears – at least in principle – as if it can be managed as a cybernetic system, albeit with the complication of non-linear feedback loops.

Technical solutions, however, have been subject to a number of criticisms from social scientists and humanities scholars (Muraca and Neuber 2018; Gardiner, McKinnon, and Fragnière 2020; Pichler et al. 2017). For instance, the level of energy production so far guaranteed by fossil fuels cannot be delivered by renewables without significant tradeoffs involving, for example, the use of land surface for biomass or large river dams for hydroelectric power. These are tradeoffs which, given current embedded environmental inequalities and social asymmetries in power and wealth, would dramatically exacerbate socioenvironmental conflicts worldwide and introduce more competition in the use of resources (Avila 2018).

The blind spots of the planetary boundaries framework risk becoming part of a "new critical orthodoxy" (see Brand 2016a, 2016b for the debate on social-ecological transformations) which provides a radical and critical diagnosis of "disastrous long-term social and environmental disruption" (Rockström et al. 2009b). But it leaves little space for more comprehensive analyses that address societal root causes of urgent problems and propose more radical solutions. It also fails to address the political aspects of structural changes required to avoid crossing boundaries. In that sense, the planetary boundary concept runs the danger of creating a new truth or orthodoxy (*orthós*, Greek for "correct," and *dóxa*, meaning "opinion" or "belief") that may overlook broad and rich debates on societal drivers, the causes of the ecological crisis, and the crossing of planetary boundaries. Unsurprisingly, the planetary boundaries concept is conveniently instrumentalized in technocratic governance efforts to serve the normative aim of "sustainable development" (Gómez-Baggethun and Naredo 2015), without challenging the underlying structural conditions of unsustainability.

Political ecologists and social ecological economists have long criticized how the framing of limits as something external that resides in nature and is *given* to humanity "depoliticizes" decisions at stake (Asara et al. 2015; Streissler 2016; Muraca and Döring 2018; Lövbrand et al. 2015). The post-political definition of planetary boundaries renders invisible, or at least relativizes, the social conflict embedded in the trajectories that transgress the boundaries, or the distribution of the benefits and impacts that they entail (Kallis 2019; Dietz and Wissen 2009; Brand and Wissen 2021). Moreover, it threatens to mask economic dynamics such as the increasing competition for scarce resources or what movements have called the "last great dispossession of the commons."

A further limit of the planetary boundaries framework lies in the sociopolitical and socioethical implications of selecting these particular nine boundaries. While Earth-system science presents an important valuation perspective with respect to specific biophysical processes included in the planetary boundaries, it does not discuss the normative and political dimensions involved in selecting these boundaries. For example, in the case of biodiversity loss, "ethics" is mentioned as a dimension of acceptability of species loss, but is mostly intended in terms of traditional conservation biology literature and not further examined. By failing to clarify and critically discuss its normative assumptions, the planetary boundaries concept limits its consideration to a rather narrow spectrum of values and worldviews and neglects perspectives voiced, for example, in environmental justice literature or in feminist and indigenous care ethics (Whyte and Cuomo 2017) and in other environmental values literature (O'Neill et al. 2018).

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) has addressed this critique by considering a wider spectrum of values besides the traditional intrinsic value of species and of wilderness (Díaz et al. 2015, IPBES 2019; for a comprehensive critique of the planetary boundaries approach in the field of biodiversity see Montoya, Donohue, and Pimm 2018). It includes, for example, relational values and contextual Nature Contributions to People (NCP), as well as Indigenous and local knowledge systems and their expressions of value, thus offering a different foundation to frame deleterious environmental change and the loss of biodiversity (Díaz et al. 2018,

supplementary materials; Pascual et al. 2017). Approaches like IPBES enable a more fruitful dialogue with concepts like biocultural diversity (Rozzi et al. 2018) or biodiversity as "territory plus culture" (Escobar 1996, 70) that call attention to the colonial expropriation and occupation of land, and the consequent erasure of Indigenous knowledge, languages, and practices as an inextricable component of biodiversity loss.[7] These variables are essential for identifying thresholds. An inter- and transdisciplinary approach that integrates natural and social science approaches and links them to diverse knowledge systems beyond the Western scientific method is necessary, as discussed, for example, under the term "traditional and indigenous knowledge" and acknowledged within the IPBES process (Díaz et al. 2018; Tengö et al. 2017).

Such an approach can also account for other worlding practices or ways of framing and embodying societal relations to nature that diverge from the mainstream project of Western development (de la Cadena 2019). From this point of view, potential barriers or obstacles to transformation already arise in the process of establishing boundaries – and not only when established boundaries are translated into political measures. For example, the risk tolerance of a society or community depends on the (often sociopolitical and power-dependent) conditions under which it can adapt to rapid change and co-determine the living conditions of its members. As, for example, Native American Potawatomi scholar Kyle Whyte (2018) points out, settler colonialism has heavily infringed upon tribes' traditionally strong resilience and adaptation ability through dispossession, forced dislocation, oppression, and cultural erasure. When ecological and epistemic redundancies are jeopardized and self-determination over territorial access, land use, and mobility are hindered, a community's risk tolerance amounts to *nihil* (Whyte 2018), as the consequences of climate change and the unequal exposure to COVID-19 by Indigenous communities through the Americas now demonstrate.

Furthermore, the planetary boundaries concept emphasizes the need to bring the "coupled human Earth System" back into a "safe operating space," which assumes that the Holocene or, at least the recent past, was safe for all people. Given societal structures of power and exploitation, this is definitely not the case. Societal values that address dimensions of the climate crisis such as the unequal distribution of risks or other aspects of climate justice may require an adaptation of the variables signaling a "safe operating space." In other words, for which part of the global population and for what purposes is a certain "operating space" safe? What is acceptable for one social group might rely upon unacceptable forms of oppression and exposure to environmental hazards for others. Global "agreement" on the maximum of 1.5°C of global heating might help sustain living conditions and ecosystem functions in some parts of the world, but puts under severe pressure people living in low lying coastal areas and those depending on the glacier functions of the Andes. More recent iterations of the planetary boundaries concept by Steffen et al. (2015, 2018; see also overview in Biermann and Kim 2020) identify sub-global levels for five planetary boundaries that have strong regional operating scales and account for inequalities at a global scale, but in light of the literature produced by the social sciences on these phenomena, much more engagement from and with the social sciences is desirable, as we discuss below.[8]

We agree with the original argument made in the Rockstrom et al. paper in 2009 that boundaries are sociopolitical constructs.[9] While they are informed by science – in other words based on the currently available (necessarily incomplete) understanding of Earth-system dynamics – their definition also requires normative and political assumptions of what are acceptable or "unacceptable" paths for humanity *in general*, to use Rockström et al.'s terms (2009a, 472). Reaching across scales, boundaries also imply a notion of (un)acceptable configurations of limits from the local to the national, regional, and global levels. Yet from a purely global perspective, if those in the global North tried to negotiate the distribution of environmental benefits and burdens within and between societies, given the dominant socioeconomic systems, it would surely result in multiple forms of inequality. This is the case as the very idea of any acceptable or unacceptable distribution path is inescapably tied to unequal gender and class relations, racism, colonialism, and imperialism, to name but a few dimensions of the complexity of social relations across scales.

Understanding social dynamics and obstacles: bringing capitalism back in

The social-ecological processes driving the planet toward multiple tipping points identified by Rockström et al. have intensified since the publication of the first planetary boundaries articles in 2009 (IPBES 2019). In a paper on accelerating climate change, Steffen et al. (2018, 2) reiterated that this continued acceleration can be blamed on "technological lock-in and socioeconomic inertia in human systems." On one hand, the authors acknowledged that "uneven distribution of causation and benefits" must be addressed (Steffen et al. 2018,

8). On the other hand, they engage only marginally with the social sciences to understand social drivers related to lock-ins and inertia.

Both the proponents of the planetary boundaries framework and critical social scientists share the conviction that business-as-usual will likely be catastrophic. However, the arguments within the planetary boundaries framework are either overly general and abstract, pointing to "humanity," "human systems," and "human population," or overly specific, identifying changes that can be implemented immediately by mobilizing (and not challenging) existing "business as usual" relations. Such a perspective runs the danger of simulating an "eco-politics" that only deals with symptoms rather than root causes of unsustainability (Blühdorn 2011; Gómez-Baggethun and Naredo 2015). This is the challenge of attempting to analyze societal issues without a conceptual framework for understanding sociocultural and political-economic processes. Solutions appear pragmatic and feasible under the unquestioned acceptance of status quo conditions (Malm and Hornborg 2014). Most sustainability policies lack this deeper analysis and so remain in the realm of "ecological modernization" (Mol, Sonnenfeld, and Spaargaren 2010), stopping short of targeting institutions, power relations, and growth logics. Moreover, they are unable to understand why ecological modernization, as well as related green economy interventions to tackle the ecological crisis, do not succeed and instead sometimes increase pressure on other ecological processes or the burden on other social groups (Wanner 2015; Lessenich 2019; Brand and Wissen 2021).[10]

As a corrective to this situation, we contend that both "technological lock-in"[11] and "socio-economic inertia" are produced by social structures of capital. We use "capitalist economies and societies" as a heuristic device for uncovering how capitalism as a social form functions.[12] The term's enduring conceptual strength is in capturing some of the essential dynamics of modern societies, core features of their historical trajectory and social structures, which otherwise remain unrecognized. Research in political ecology and social ecological economics has explored how the structural drivers of capitalism frame practices, institutions, and actions that cause ecological destruction (Schnaiberg 1980; Spash 2012; Martínez-Alier 1987; Pichler et al. 2017; Pineault 2018; Pirgmaier and Steinberger 2019; Mattioli et al. 2020; Peet, Robbins, and Watts 2010). Authors working from these vantage points, highlight how social relations of production, reproduction, and living, as well as questions of property, contemporary enclosures of the commons, power, and domination are explanatory factors of growth, acceleration, and ecological crisis.[13] Because the structures and dynamics of capitalist societies are full of ambiguities and contradictions, the issues a study of capitalism illuminate can be entry points for confronting ecological crises more effectively.

A capitalist economy can be defined in a number of ways. Initial alternatives are through its social relations of property, which is based on the dual separation between labor and capital (Marx 1996 [1867]; Wood 2002), or between valued and devalued labor in the reproductive sphere (Mies 1998; Barca 2020). It can also be demarcated in terms of how markets organize economic relations (Polanyi 2001 [1944]) or how the commodity and exchange-value form organizes the relation to both objects in general (Kosoy and Corbera 2010; Robertson 2012) and the means of production (Minsky 2008). The capitalist economy can also be defined by its expansionary drive and imperative of accumulation that directs its development (Luxemburg 1951 [1913]; Foster 2005) and governs its relation to nature (Altvater 1993; Saito 2017). For the purposes of this article, we propose an initial definition of the core features of this mode of production, reproduction, and living and outline its societal relations to nature in the following key points.

First, capitalism is a monetary production economy (Graziani 2003) where societal wealth "presents itself as an immense accumulation of commodities" (Marx 1996 [1867]). In such an economy, rights and capacities to mobilize labor power, to transform nature, and to create and dispose of artifacts take on a monetary form. The unequal accumulation of money (either in the form of credit or savings) implies unequal power over nature and society (Hornborg 2019).[14] Production is oriented toward profit, not social needs – what classical economists understood as the subsumption of use value by exchange value. Monetary profits are the dominant way surpluses are extracted and privately appropriated (another form is taxation). Private for-profit investment is the main driving force of growth and change (Lavoie 2014). Competition in various forms (from relatively free to monopolistic) coerces capitalist firms to invest and direct their monetary surplus toward further expansion in a constant search for returns (Crotty 1993). The capacity to spend for investment purposes is thus a dominant form of social power (Kalecki 1965). Capital investment is the primary source of "technological lock-in," by fixing capital in tangible and intangible forms such as privately-owned machines and productive equipment, buildings, infrastructures, communication systems and platforms as well as patents, brands, proprietary knowledge, and data – all of which are exploited to generate profits and rent accumulation

(Foster 2005; Gould, Pellow, and Schnaiberg 2004; Klitgaard 2013). And it delineates the future ways of producing and consuming (Ceddia 2020), and thus, alongside other social processes discussed below, for-profit investment governs the metabolism and relation to nature of capitalist societies (Kronenberg 2010; Pichler et al. 2017).

These social relations are structured around the asymmetry between dominant classes – and their top managers – that control the investment process for their private benefit and thus accumulate capital in a monetary form, versus classes obliged to sell their labor power to earn the income necessary for their subsistence at varying levels of affluence (Robinson 1956; Aglietta 2000 [1979]). This asymmetry is furthermore intertwined with gendered, racialized, and imperial relations of domination (Robinson 1983; Federici 2004; Brand and Wissen 2021). New intellectual property regimes, whether for COVID-19 vaccines or seeds, add to the exclusionary logic. Inequality is not an outcome of capitalist social relations: it is their foundation.

In today's global economy, the process of capital accumulation delineated above is particularly embodied in large corporations that must strive to grow to maintain their economic dominance in the markets in which they are embedded. They must also actively shape and condition demand for their output to maximize their profits, to structure their commodity chains and circuits to minimize costs and externalize burdens, and to engage in innovation to defend the value of long-term fixed capital assets against competitors and state regulation (Eichner 1976; Roy 1997; Foster and McChesney 2012; Crotty 2003; Suwandi, Jonna, and Foster 2019). In contrast, as a class, wage-earners materially depend on capitalist production and expansion for their livelihood and subsistence which complements provisioning and care produced in the reproductive sphere (Biesecker and Hofmeister 2010; Fine, Bayliss, and Robertson 2018). At the same time, capitalists depend on the effective demand of wage-earners to absorb the produced output and participate as consumers in capitalism's expansionary logic. This conflictual interdependency between capital and labor varies through time and space and leads to distinct phases of capitalist development or accumulation regimes which also have distinct relations to nature (Boyer 2000; Görg et al. 2020). For example, during the postwar period, economic growth as measured by gross domestic product (GDP) regulated this conflictual relation in the global North, and was the material basis for social and political emancipation, democracy, and cultural flourishing for a large number of people (albeit never for all) inside the limits imposed by capitalist development and at a considerable ecological cost (Pineault 2021. Some emerging economies such as China are seeing similar developments. Economic growth has supported and, to a certain extent stabilized, capitalist societies by facilitating distribution and material participation, thereby reducing class conflicts and sustaining the output legitimation of welfare democracies (Kallis et al. 2018; Görg et al. 2020). In these circumstances, economic growth has become the material basis of social life and of the societal organization it has enabled (Schmelzer 2016).

This is why, when faced with the impending crisis of economic growth in early industrialized countries, brought about by ecological and social constraints, governments intervened to salvage growth at any cost via – inter alia – neoliberal adjustments including the deregulation of labor and financial markets, the commodification of public services, and austerity policies. From a stabilization vantage point, growth then turned into the main driver of ecological instability and social inequalities. From a biophysical perspective, it could be argued that capital has mostly served to accumulate ever-higher concentrations of carbon dioxide (CO_2) in the Earth's atmosphere, as well as future emissions locked into the existing stock of material artifacts and infrastructures that rely on extracting fossil fuels (Krausmann et al. 2020). On the basis of social position, these compounded crises (ecological, economic, and social) are felt earlier by some than by others, and they negatively impact some people's lives whereas others might benefit. Thus, to critically engage with the contradictions between nature and capitalism means also to stress that there is no one global ecological crisis that means the same thing to all humans: there are always winners and losers (Dietz and Wissen 2009). However, the capitalist growth imperative and its consequences that we have outlined above do not determine the economic relations of contemporary societies. As we will argue, other "economic logics" co-exist with capitalism and are alternatives to its destructive logic.

Second, critical social science has produced much evidence that governments, states, and international political regimes – understood as institutional apparatuses that formulate and implement public policies – play a major role in the ongoing escalation of capitalist growth and related transgression of planetary boundaries (Hausknost 2020; Görg et al. 2017; Brand, Görg, and Wissen 2011). Rather than being neutral regulators, they create the overall institutional, legal, and infrastructural conditions for the growth economy. This is partly because governments and the state are financially dependent on a functioning capitalist economy. The capitalist

growth imperative and its unsustainable implications are thus largely inscribed within the state's own rationalities, institutions, bureaucratic practices, and subjectivities. This is one of the reasons, for example, why it has been so difficult to implement effective policies against the planned obsolescence of products: a successful elimination of planned obsolescence and a shift toward a service economy (based on repairing and reusing) would inevitably reduce the profit margin of companies and therefore impact economic growth, which has effects on the political stability of governments (as the COVID-19 lockdown has shown) in the absence of radical institutional changes.

At the same time, the state is a field of societal contest (Poulantzas 2013 [1978]; Jessop 2007; Bretthauer et al. 2011). For instance, there have been huge achievements of decommodification, of a number of spheres including the workforce, education, public services, and social security through the welfare state because it put political priorities over the motive of profit making (Esping-Andersen 1990). These achievements have been supported in the past by a reallocation and redistribution of economic growth to those services and have been heavily jeopardized by the neoliberal restructuring of societies toward unrestrained economic expansion without redistribution (Harvey 2010; Dardot and Laval 2017). This is endangering the stability of welfare democracies worldwide and opening the doors to authoritarian regimes (Kallis et al. 2018). The challenge is how to embrace constraints on expansion via democratization and not through authoritarian crisis solutions that focus on the competitive advantage of one nation (or certain racial groups within nations) at the expense of all others.

Third, capitalist societies are growth economies that violate basic conditions for the reproduction of biophysical systems. Because economic processes are – like biological ones – entropic with respect to the system in which they are embedded, they transform available energy and complex matter into structures and release waste to the environment (Georgescu-Roegen 1971). While biological processes mostly depend on the temporal flow of solar energy to regenerate and build complexity, growth economies accelerate these processes by using fossil deposits (essentially highly concentrated solar energy that is available at will, but is not renewable) and expand the capacity to exploit more resources (Muraca and Döring 2018). In contrast to traditional agrarian societies primarily based on metabolizing biomass, industrial societies have developed on the basis of a fossil energy-based metabolism (Huber 2009; Fischer-Kowalski and Haberl 2007). The shift from traditional agrarian to industrial metabolism is an ongoing process that was slowly prepared and enabled by a process which Marx calls primitive accumulation, which among others takes the form of colonialism and – through it – the appropriation of cheap nature (plantations or mines in the colonies) and cheap labor (enslaved and forced labor) (Harvey 2014; Moore 2015; Haraway and Tsing 2019). More specifically, the growth imperative of capitalist societies has its biophysical basis in an ecologically and socially unsustainable metabolism, and the destruction of the commons. This metabolism can be analyzed both in terms of the throughput of energy and material and of the accumulation of biophysical stocks that further lock-in growth (Krausmann et al. 2017). This applies in particular to fossil fuels (Georgescu-Roegen 1975; Altvater 2006; Huber 2009; Malm 2018), but also to other minerals, including metals, and to the human appropriation of net primary production (HANPP) of the world's plants which provokes land-use change and biodiversity loss (Haberl, Erb, and Krausmann 2014).

Much vaunted decoupling between material use and economic growth as measured by GDP – resulting in reduced material intensity or in improved material efficiency – veils the real problem from a metabolic perspective, as do the effects of changing spatial patterns in production and consumption.[15] Although GDP may grow faster than material use (a trend hailed as improved resource efficiency), material use often continues to grow in absolute terms (Haberl et al. 2020; Wiedenhofer et al. 2020). Even stagnation of per capita resource extraction and consumption in the advanced capitalist core appears to depend at least partially on growing imports, especially of fossil fuels (Schaffartzik, Duro, and Krausmann 2019).

Approaches to social-ecological economics, ecologically grounded political economy, political ecology, and social ecology complement the notion of escalating societal metabolism by emphasizing the conflictual and institutionally-mediated forms of the societal appropriation of nature. Moreover, the fulfillment of historically contingent basic societal needs such as food and housing, mobility and communications, health and clothing, and their biophysical dimensions are inseparably linked to symbolic and discursive dimensions (Becker, Hummel, and Jahn 2011; Görg 2011). For instance, an automobile is not just a vehicle with certain biophysical properties but stands also for a particular way of production and living. More specifically, the car is constituted by a powerful automotive industry and numerous wage laborers and is linked to values such as freedom, individual independence, masculinity, and progress (Mattioli et al. 2020).

Fourth, critical social science disposes of a large body of research that shows how and why the capitalist growth imperative is deeply inscribed into everyday practices, involving social norms and material arrangements (Wilhite 2016; Guillen-Royo and Wilhite 2015; Sahakian and Anatharaman 2020; Brand and Wissen 2021). In the sociology of consumption, this has led to reflections on how such routinized and habitual practices are difficult to change. The growth imperative – also framed as "development," especially in the global South – is entrenched not only in existing institutions but also in overall societal norms, values, and discourses (Escobar 1995) to the point that it operates as a mental infrastructure (Welzer 2011) or a subtle mode of subjectivation (Muraca 2020). And yet, most mainstream efforts to promote more sustainable modes of living tend to focus on better informing individuals, nudging people to behave better, encouraging green consumerism, or introducing more efficient units of technology, approaches which have been criticized as being too limited in their understanding of social life (see Shove 2018). Critical social science understands the societal addiction to growth as a powerful societal imaginary that can be challenged by radical social experiments, movements, and alternative, collective practices (Van Griethuysen 2010; Castoriadis and Murphy 1985; Muraca 2013; Schmelzer and Vetter 2019; Sahakian et al. 2021).

Fifth, our broad understanding of capitalism sheds light on unequal global social relations. Internationally, societal metabolisms are highly differentiated. Research has shown that they are structured by unequal exchange between core and periphery which have coupled surplus-absorbing and -producing economies and societies (Boatcă 2015). Though global growth is often seen as the remedy for these inequalities, in fact it tends to lead to international polarization in metabolic rates, contributing to inequality in the transgressing of the planetary boundaries (Duro, Schaffartzik, and Krausmann 2018) and accelerated destruction of life enabling commons systems. Moreover, the unsustainable patterns of production and consumption that cause the transgression of planetary boundaries are based on an – in principle – unequal appropriation of and access to natural resources, natural sinks, and labor power between global elites and (upper) middle classes, on the one hand, and subaltern groups, on the other, across both the global North and the global South (Brand and Wissen 2021).

By adopting a more complex perspective inspired by critical social science, sustainability research can develop tools to better understand the unequal distribution of material appropriation of societies, not only in a purely descriptive manner (cf. Steffen et al. 2015, 8) but analytically as a relational feature of societies and economies locked into relations of unequal ecological exchange (Hornborg 2019) and the dynamics of "cost-shifting" (Kapp 1978 [1959]; Zografos and Robbins 2020) of environmental constraints toward least powerful polities and economies.

Finally, capitalist societies are reproduced by and reproduce an uneven order of knowledge that manifests itself both in the celebration and rejection of scientific rationality. Natural as well as social sciences tend to promote technocratic and expert discourses as canonized by scholarly research to the detriment of other forms of knowledge or they tap into "local" or "traditional" knowledge when it can be made (economically) productive (Lander 2000). Following the same logic, far-right politicians as climate-change deniers tend to delegitimize expert knowledge in the name of an alleged "common sense of ordinary people" in order to promote populist agendas aimed all the same at excluding alternative knowledge systems. Critical social science, and particularly feminist as well as decolonial approaches from the global South, strongly question the Western/modern conception of nature as separate from human societies and instead highlight their interdependencies, relationality, and co-productivity (Escobar 2012; Santos, Radicchi, and Zagnoli 2019). For instance, the emphasis on territoriality put forward by Latin American scholars (Porto-Gonçalves 2001; Alimonda, Toro Perez, and Martin 2017; Svampa 2018) has shed light on how those relations between nature and culture differ according to specific power configurations in specific places. According to these authors, the "globalist perspectives" of the body of literature within sustainability studies are universalizing Western perspectives (Alimonda 2019; Moreano, Molina, and Bryant 2017). The planetary boundaries framework risks reinforcing not only the invisibilization of other forms of knowledge in the diagnosis of the current crisis, but also the suppression of solution paths embedded in a plurality of ways of inhabiting the world in the global South and in the global North by suggesting top-68down technocratic solutions such as large-scale climate engineering or climate-smart agriculture projects (Newell and Taylor 2018; Karlsson et al. 2018).

From this briefly outlined theoretical perspective, respecting planetary boundaries to ensure a "safe operating space for humanity" requires that capitalism's logic of growth, domination, and exploitation, as well as its attendant social processes and societal

metabolism, are so constrained that accumulation would be severely impaired and disrupted, throwing the system into a prolonged state of crisis (Blauwhof 2012; Shao et al. 2017). Capitalist societies generate complex dynamics that are difficult to control and to redirect into a socially and ecologically appropriate direction. Adequate policies to promote far-reaching social-ecological transformations at various spatial scales are structurally overburdened not only by the complexity of ecological problems and crises but also by societal structures and processes. Therefore, political will, better designed policies, more financial resources, and new modes of governance linking classical political actors with societal stakeholders are important. However, a more nuanced understanding of the socioeconomic and cultural lock-ins of destructive societal relations to nature is necessary and already well examined within critical social science.

Examining planetary boundaries from this perspective changes the scope of the social-ecological transformations needed to remain in a metabolic "safe space." It underlines the strategic need to take into account the dynamics and variability of the capitalist mode of production, reproduction, and living, as well as its social power relations and social inequalities within and across societies. In contrast to the use of "humanity" as a homogenous "we" in the planetary boundaries framing, a critical analysis of dominant social structures and processes and already existing alternatives makes power relations visible. It draws attention to the power-infused institutionalized organization of the societal metabolism – or more specifically to capitalist social relations and societal relations to nature – and its highly destructive character. Instead of holding onto planetary boundaries as the rationally incontrovertible moral space within which political decisions should operate, critical social science keeps open the space of moral and political deliberation in the face of the ecological crisis.[16] Doing so implies, for example, highlighting epistemic justice and the conditions under which weaker actors and subaltern communities can articulate value and knowledge systems in their own terms (Temper and Del Bene 2016). It thereby renders political struggles and conflicts visible and exposes asymmetrical power relations of norms and values. And it highlights the contested character of those relations and the variety of alternative modes of living that are already embodying imaginaries and practices of self-limitation and responsibility toward nature. In the following section, we sketch possible directions – while recognizing the sociopolitical obstacles to social-ecological transformations.

Societal boundaries for just social-ecological transformations: ways forward

In the previous section, we presented some crucial elements of an analytical framework to understand the escalatory logic of capitalist societies and how it is deeply inscribed into social structures, norms, and values. The question that then follows is how to unwind this logic. How can the metabolism of contemporary societies be de-escalated, and in a way that is socially just? Critical social science has contributed over the years not only to a better understanding of the drivers of unsustainability, but also to identifying possible entry points for more sustainability and for what far-reaching social-ecological transformations might look like. In doing so, it amplifies otherwise neglected voices and emphasizes already existing alternatives. A critical social science perspective not only offers an analysis of the dominant capitalist system but also contributes to supporting a livable, just, and democratically organized future where politics and societal relations are guided by the notion of a "good life for all" within planetary boundaries.

The focus is on *conditions* because it is not so much the achievement that is up for debate, but rather the substantial conditions that are a field for ethical and political contestation.[17] On one hand, critical social science reveals what should be a "no-go" for societies invested in framing structural conditions that impede the crossing of planetary boundaries. On the other hand, it identifies and brings into public debates certain "must-haves." Crucial requirements for the envisioned social-ecological transformation processes include both *principles* and values, such as reciprocal responsibilities and solidarity, to take successful and failed experiences seriously, and *criteria* for establishing substantial conditions for a good life for all and for the fulfillment of socially negotiated needs.

In asking what kind of worlds "we" want to live in, critical social science critically discusses how the "we" participating in the deliberation is or can be constituted, and how the conditions for well-being or a good life are to be defined and framed, in concrete historical moments and contexts beyond a solely Western understanding of prosperity. In this sense, critical social science is highly policy-relevant as it reveals unsustainable and unequal social relations as well as societal relations to nature and highlights their institutional embeddedness within and articulations with power relations (and their ecological fallout). Public policies and political decision makers play an important role, but they are not the sole audience of research results: the research is intended to also challenge different affected actors to place their interests and values into a broader

context and to reflect critically on contextual conditions, along with their practices, interests, and strategies.

In the subsections that follow, we begin by describing the paradigm of "societal boundaries" as a form of societal *self-limitation* for social-ecological transformations. We then discuss similarities with existing perspectives, and what the societal boundaries concept brings to the discussion. We then address the central questions of *how*, *by whom*, and *for whom* societal boundaries are defined and introduce the debate on systemic alternatives to capitalist principles. We conclude with reflections on governance systems and the necessity of binding rules.

Societal boundaries: a new paradigm emerging out of concrete experiences

Societal boundaries need to be defined to cope with the deepening ecological crisis and its devastating socioeconomic impacts – especially for those who already live under precarious conditions (see also Biermann and Kim 2020, 514). Instead of being objectively given by biophysical processes, societal boundaries, as we understand them, emerge from contested societal processes that lead to collectively defined thresholds that societies commit not to trespass. These limits pertain to poverty, inequality, ecological destruction, injustices, subordination, exploitation, consumption, defense of the commons, and so forth. Societal boundaries are structural boundaries, particularly set by political rules within societies, that secure the material and energy prerequisites toenable substantial conditions for a good life for all. There is no guarantee that societies would democratically decide a path toward self-limitation nor that this can be achieved via consensus formation. This is where progressive social movements and other political actors, political education, and alternative projects come in: they reinforce and support sociocultural values and norms rooted in social justice considerations, which in turn must be embedded in social relations and institutions. To become socially relevant, the value of such boundaries is more or less accepted throughout societies, and it informs policy-making processes.

Critical social science work can help to formulate *politics of self-limitation* and demarcate *societal boundaries,* social conditions, and sociopolitical measures to respect these constraints – for example by keeping fossil fuels in the ground and organizing social life around alternatives with lower emissions and less devastation of livelihoods. It also keeps open space for critical questioning. The central idea of *societal boundaries* is a change of analytical and political perspectives: rather than thinking of the planet as bounded, we insist to think of the planet as potentially abundant – as long as we limit ourselves collectively and make space for others to share the resources it has to offer in a responsible way among current living and future generations. This is also a perspective of respectful cohabitation with non-human others (Kallis 2019; Akbulut et al. 2019; Hickel 2019). Boundaries, planetary or societal, are not given; rather they are always relational, a function of human intentions, actions, practices, and interactions – and it is these factors that should be bounded to make space for all. Shifting the focus from boundaries and limits to *self-limitation* emphasizes that this is a social challenge and a process rooted in forms of participation, collective self-determination, and democratic deliberation. For centuries, the democratic governance of the natural commons, as common wealth in the global North and South, gave us practice in self-limitation. Self-limitation questions the idea of considering environmental problems in terms of a technocratic challenge to address, which can implicitly include shifting the boundaries or continuing with expansion all the way up to the "no-trespass" point.

The term self-limitation echoes the literal meaning of *autonomy*, or giving to oneself one's own laws or rules as an act of self-government. In the traditional liberal understanding, autonomy is rooted in the idea of an independent, individual self that is not determined by external norms and therefore free. Yet in the radical tradition of autonomism, it is intended as a social relation and a collective process of self-determination via local, horizontal, anti-authoritarian practices (Alcoff and Alcoff 2015). What is common to both is the idea that freedom implies giving oneself rules of conduct and therefore limits, instead of following arbitrarily or externally imposed ones. It constitutes the very foundation of democracy as self-rule. Rather than *ending* where someone else's freedom begins, freedom as autonomy *begins* with the self-imposition of limits to make space for others to simply be (Alcoff and Alcoff 2015). When considered in its societal dimension, autonomy resists its opposite, heteronomy, or the functional regulation of conduct according to given principles, such as the so-called law of the market or the mantra of austerity and growth. As such, autonomy as collective self-limitation and self-determination requires taking responsibility for one's own destiny and giving to oneself, as a community, self-imposed norms instead of following external impositions (Gorz 1980; Castoriadis 2010; Fuchs, Sahakian, et al. 2021; Muraca 2013). In this way, autonomy implies *liberation* from the structural and mental constraints of the capitalist imperatives. As Gorz writes:

> [T]he point is to subject economic and technical development to a pattern and orientations which have been thought through and democratically debated; to tie in the goals of the economy with the free public expression of felt needs, instead of creating needs for the sole purpose of enabling capital to expand and commerce to develop (Gorz 1994, 8).

As a collective, complex, and conflictive societal process, with respect to sustainability and social-ecological transformations, self-limitation can be framed in terms of enabling the conditions for a good life *for all* rooted in the actual freedom of not having to live at the expense of (human and nonhuman) others.

The idea of autonomy as self-limitation is present in different variations in many traditions, societies, and communities across the world. For example, Gandhi's notion of *swaraj* implies autonomy and freedom of the individual and the community as bound by responsibilities and duties toward other individuals and communities, and thereby necessarily encompassing spiritual or ethical living within limits and nonviolence, including toward nature (Shrivastava 2019). Embracing autonomy as guiding principle also implies making space for other world-making practices in a pluriverse of socio-natural configurations (Escobar 1995), instead of forcing them into the so-called "one-world world" of the Western dominant model of development *as* growth. The pluriverse is "a world where many worlds fit" (as the Mexican Zapatista movement prominently coined it (Holloway and Peláez 1998)), that enables alliances across different social and environmental movements and resisting communities coming together as "a political ecology of practices, negotiating their difficult being together in heterogeneity" (Blaser and de la Cadena 2018, 4).

In this sense, a more radical understanding of social-ecological transformations as one that considers the root causes of the problems and that adds nuance to the underdeveloped normative statements of the planetary boundaries proponents. This is not an easy task because it entails rejecting the escalatory mode of production and of living that marked most of the attempts at social transformations in the 20th century, a perspective that aimed to secure social well-being and emancipation for some inhabitants of the planet at the expense of human and nonhuman others. It implies building alliances to reinforce alternative conceptions of quality of life and well-being, which are neither centered in accumulating material possession of goods, nor in success though exploitation. Instead, it involves relational, spiritual, and affective dimensions of well-being rooted in the principles of equity, solidarity, cooperation, participation, ability to redistribute, and co-habitation of diverse modes of living (Gibson-Graham 2019; Bollier and Helfrich 2021; Barkin and Lemus 2016).

Clear alternatives that are envisioned and embodied in concrete social experiments and practices across the world need to be developed, as aligned with principles for just social-ecological transformations, and as involving strong alliances across sectors. Faced with this challenge, many questions arise. How can social emancipation processes that respect ecological considerations be imagined and implemented? What would political and cultural interventions against the endless creation of artificial desires, which fuels the massive overconsumption of the global middle and upper classes, look like? What can actually be learned from those modes of living that have put forward sustainable adaptation, and from those communities who resist developmentalism and growthism at any cost in their quest for a good life and satisfaction of needs, particularly among communities in the margins of the global South? Such questions foreground the need to consider power arrangements, as well as the possible winners and losers of political strategies for "sustainability." Who is likely to pay for changes and how do changes affect different social groups differently? In which segments of society will it encounter critique and resistance and why? How can global transformations be built without imposing universal paradigms that absorb or condition other worldviews, especially in the global South? How can fruitful alliances be consolidated instead of imposing solutions via technocratic design?

When it comes to experiences of and the potential for social-ecological transformations, critical social science considers progressive social movements and radical social experiments as well as the ambiguous role of the state (as discussed below). Those movements often display an intersectionality of struggles (organized along the lines of race, gender, urban, or agrarian as well as in accordance with labor or environmental conditions) that is emblematicof their efforts at coalition-building, and they harbor alternative values, both by imagining alternative futures and by enacting different societal relations to nature (Asara 2016; Barca 2020). Against an alleged common interest of "humanity" in protecting the environment, alternatives to the escalatory dynamics of capitalist societies often emerge out of social-ecological conflicts and mobilizations. Campaigns like *Fridays for Future* (Wissen 2020; Wallis and Loy 2021) or anti-extractivist protests in many countries of the global South (Svampa 2018; Martínez-Alier 2020) are gaining in momentum and effectiveness. Food-sovereignty movements and alliances are also proliferating at the frontlines of

defending Indigenous knowledge, *commoning* practices, and advancing systemic transformation of fossil fuel-driven food systems. Existing social movements, particularly in the global South, are successful in stopping the growth in metabolism or trying to do so across the world, many of them under the banner of "environmental justice." In many instances, forms of mobilization have led to successful outcomes, such as the halting of mining projects in Argentina (Wagner and Walter 2020). In a recent mapping of 649 cases of resistance movements to fossil fuel and low carbon-energy projects, over a quarter of such projects have been canceled, suspended, or delayed – demonstrating the success of place-based movements (Temper et al. 2020). Indigenous resistance to land dispossession in both the global North and global South also claims attention toward biophysical limits and boundaries, along with the need for a renegotiation of social boundaries in the form of self-limitation that makes space to all for a good life. Here, a range of understandings and practices of "the good life," quality of living, and well-being emerge and often overlap (Manno and Martin 2015). Organizers of these efforts also invented political slogans which became prominent in recent years such as "leaving oil in the soil" from movements in Nigeria and Ecuador. Bottom-up mobilizations for more sustainable and socially just uses of the environment occur worldwide, yet environmental defenders are frequently members of vulnerable groups and are at a high risk of criminalization, physical violence, or assassination – as documented in the analysis of around 3,400 cases in the *Environmental Justice Atlas* (Martínez-Alier 2020; Scheidel et al. 2020).[18] Against this background, we outline some crucial contributions from critical social science to better understand principles and criteria of social-ecological transformations.

New processes: Integrating social foundations and well-being with "boundaries"

In recent years, a growing body of literature suggests that some form of social "boundary" is required for sustainability transformations. One visual framework which combines planetary boundaries with social foundations is Kate Raworth's (2017) "doughnut economics," with eleven dimensions of the social foundation based on governments' priorities for Rio + 20, out of a total of eighty submissions. When social foundations are met without trespassing planetary boundaries, a "safe and just space" is attained – through an appealing infographic called being "in the doughnut."[19] An interdisciplinary team of social and environmental scientists have applied national data to the donut framework to determine where and in what way "a good life for all within planetary boundaries" might be attained at a national level (O'Neill et al. 2018). This group calculated what social thresholds are achieved and what biophysical boundaries are transgressed, drawing on seven biophysical and eleven social indicators for 150 countries.[20] No country is currently able to respect planetary boundaries and guarantee the right to a "good life for all" as defined in the study, although an analysis based on cities or regions might provide different results. Two strategies are suggested by the authors to reduce resource use: 1) to follow degrowth strategies and a steady-state economy in rich nations and 2) to restructure and improve physical and social provisioning systems. Their understanding of provisioning systems draws on the work of Fine, Bayliss, and Robertson (2018), which recognizes the role of power, culture, and regulations in how goods and services are produced, distributed, and consumed.

It is important to question the representation of nature-society relations in two circles, where one (nature) is the external ring that include the other (society). Raworth's donut framework does not place an explicit upper limit on social foundations; they are implied, in relation to the upper limits of planetary boundaries. However, living the good life in one context might hinder the possibility for others, elsewhere, to do so. As far as the "too much" for some is a function of the "not enough" for others, upper limits (not only ecological ones) are necessary, as trespassing such limits would result in achieving social foundations at the expense of others ability to do the same. In a societal boundaries approach, outer limits are social-ecological. A societal boundary, for example, could place a limit on the development of commercial spaces – as a limit to the encroachment of the public commons, toward not only curbing the spread of consumerism, but also that of energy-intensive indoor spaces that are artificially heated or cooled, and unaffordable for small, local producers. In such an approach, theories of social metabolism and societal relations to nature are brought together in a way that encourages us to rethink the model in terms of complex, dynamic, reciprocal, and systemic interrelations.

Beyond the donut model and the calculations provided by O'Neill et al. (2018), the question of how to relate human needs to resources is one that requires social debate and participatory approaches. Such an approach is proposed in the notion of "sustainable well-being" (Gough 2017) and is the main thrust of the "Living Well Within Limits" project which emphasizes how citizens might engage in deliberation around identifying how their needs can

be met or satisfied in relation to energy sources and systems of distribution (Brand-Correa and Steinberger 2017). To address this situation, the notion of consumption minima *and maxima* has been developed recently around the notion of "consumption corridors" that join notions of environmental justice and well-being (Fuchs, Steinberger, et al. 2021; Fuchs, Sahakian, et al. 2021; Wiedmann et al. 2020). Consumption corridors is a societal boundary proposal based on the assumption of generalizable needs common to all. Although a universal conception of "human needs" is controversial to some people, it can refer to general commonalities for a "vague and thick" conception that identifies essential components of a good life common to all people, such as bodily integrity, but leaves open their concrete specification to sociocultural determinations (Nussbaum 2003).

Max-Neef (1991) distinguishes between needs and satisfiers, where satisfiers are the many different ways of satisfying a need. Satisfiers can then be defined through a societal process, while needs are articulated across different dimensions that cannot be ranked; for instance the need for affection can neither replace nor compensate for subsistence. Within consumption corridors, socially deliberated need satisfaction is based on the assumption that meeting needs should not infringe upon the possibility for all people to do the same, now and in the future. This implies an upper limit to consumption and use of services.

While consumption corridors have not yet been operationalized, the concept explicitly places a focus on what processes are needed for designing them. Central to the idea are transdisciplinary approaches that account for a diversity of experiences and forms of knowledge. Recent developments in relation to consumption corridors increasingly consider the role of social practices, or how everyday life is played out in relation to social norms and people's dispositions and material arrangements, in relation to need satisfaction. However, the societal boundaries that we are proposing here would encompass consumption but also reflect back on systems of provision and production processes that facilitate some forms of consumption over others. Usually, the norms of production are set by powerful investors with interests in expanding production, dependent on creating ever-more extensive desires. In considering research and development dynamics and current norms around the production and distribution of commodities, socially set boundaries would imply processes of industrial conversion and the phase-out of ecologically problematic branches, such as the automotive or aviation sectors, coal mining and burning, and dramatic reductions in industrial agro- and aquacultures. These efforts would need to go hand in hand, for instance, with respective social-ecological industrial policies (Pichler et al. 2021), all of which would necessitate structures and processes of economic democracy (Harvey 2010).

Establishing societal boundaries through diverse radical alternatives

Alternatives to growth-driven and consumerist capitalist modernization must pursue diverse strategies by strengthening the pluriverse of radical or systemic alternatives that exist across the world and/or by aiming at transforming the state, be it from outside or from within, wherever possible (Jessop 2007). Many alternatives are reassertions of ancient and traditional approaches, emerging from marginalized peoples and movements of resistance to the dominant system. Others arise from within modern or industrialized societies, often from sections of the middle class or elite urban population that are disillusioned with their own lifestyles and sensitive to the inequities and unsustainability they perpetuate. Examples of the former are struggles against extractivism, development and Western modernity, and concomitant revival or assertion of Indigenous or other community worldviews and practices centered on the good life across the global South, such as *buen vivir*, *kawsak sacha*, *kametsa asaike*, *sentipensar*, *ubuntu*, *kyosei*, *hurai*, *prakritik swaraj*, and *minobimaatisiiwin*, among others (see Appendix 1). These and many others demonstrate the existence of approaches that center on solidarity, interconnectedness, reciprocity, embeddedness within nature, health, and other such principles or ethical values. They share common threads with a number of alternatives emerging from industrial society, including degrowth, ecosocialism, ecofeminism, conviviality, earth spirituality, pacifism, deep ecology, social ecology, commons, environmental justice, eco-anarchism, working-class environmentalism, and rights of nature. A diversity of alternative practices also exists around the world, including agroecology, transition movement, ecovillages, *commoning*, solidarity economy, slow movement, worker-led production, energy and food sovereignty, free software, deep just transitions informed by climate justice, and others (see Kothari et al. 2019).

Individually and collectively these conceptions embody *alternatives* in worldviews and practices that challenge the structures of inequality, oppression, and unsustainability and replace them with those that promote justice, equality, and sustainability. They share a rejection of neoliberal globalization, and embrace forms of selective economic

deglobalization (Bello 2008; Novy 2020) which involves dismantling the "one big market" (Polanyi 2001 [1944]) coordinated by global financial markets and sustained by fossil-fuel logistics of airports, motorways, and cargo shipping. Under certain circumstances, the collective self-determination of communities requires control over their own boundaries to protect subsistence and livelihood sovereignty against global trade and investment agreements such as the European Union-Mercosur Treaty with respect to food systems.[21] They point to a comprehensive transformation in political, economic, social, cultural, and ecological spheres of life, guided by the ethical values noted above.

There is agreement in critical social science that the role of the state in social-ecological transformations is ambiguous. Due to the strategic selectivity of the state in capitalism, it tends, as outlined earlier in this article, to be part of the problem. Its dependence on growth and taxes pushes state agency toward securing unsustainable structures, processes, and power relations even with respect to policies that, at first sight, intend to deal with the ecological crisis. In many countries, the repressive side of the state to defend the interests of elites is much stronger than its distributive side, often acting openly and in a one-sided manner in the interests of capital and oligarchies. The boundary between capital and the state is blurred in the context of thin "market democracies," with a growing literature on the "hollowing out of democracy" and the rise of the new right (Bello 2019).

But the state can also be part of the solution, as a terrain for contestation. This depends, however, on changing the concrete form of the state through strengthening decentralized units (municipalities) and democratizing both public institutions of basic provision (education, health, care) as well as economic policy making. In the usual Eurocentric and "modern" approaches to the state and state theory, this is a productive and important debate (Eckersley 2021). In many countries, the state is ambiguous in the sense that it largely secures *unsustainability*, while at the same time it has the potential to give legal and financial recognition to at least some social-ecological achievements (see discussion above). The state also has the potential to impose limits on excessive extraction and exploitation, for instance by implementing income and wealth caps (Buch-Hansen and Koch 2019). Furthermore, public authorities play a key role in shaping decommodified provision systems (Bayliss and Fine 2020; Eckersley 2021). The question remains how to practically enact such limits that lead to more durable and institutionalized forms of practices and how a democratic governance of limits can be implemented across various spatial scales (Lang and Brand 2015). This emphasis can lead to consideration of what an "anticipatory governance" of limits or boundaries, instead of existing reactive adaptations, would look like (Biermann and Kim 2020, 508).

The currently dominant form, the nation-state, has repeatedly demonstrated a serious inability to go deeper and beyond, at best, a welfare approach, and this has quite obviously failed to deal with global issues like the climate crisis. There is a certain centralization of power involved in this form of state, and the emphasis on liberal "democracy" that bolsters it seems to be more fit for the capitalist economy than for an ecologically sensitive, people-centered economy. For instance, Gandhian *Swaraj* in India envisions a society without a centralized state. But even if this was possible, there would still be the question of coordination and governance at large scales, given that in an interconnected world no community can exist in isolation, and given that ecosystems, cultures, and economies exist at larger scales. The experience of radical democracy attempted by the Zapatista and the Kurdish autonomy movements are instructive, as they are of a significant scale, as are movements of Indigenous self-determination in Latin America or of self-rule/*swaraj*/radical ecological democracy by communities in central India (Leyva-Solano 2019; Esteva 2019; Aslan and Akbulut 2019; Zografos 2019; Shrivastava 2019; Kothari et al. 2019, Kothari and Das 2016). Meanwhile, as the nation-state will likely continue to exist for the foreseeable future, movements to make it accountable, transparent, and responsive, especially to the needs and rights of the marginalized, and to socioecological sustainability, are as important as those seeking transformations in the nature of the state and of power itself. In that sense, the state at various spatial scales from the local to the international is also an agent and terrain where policies for social-ecological transformations are possibly formulated and implemented (see discussion below). The economy and economic actors, respectively, are not only profit-driven companies but could in principle also serve the common good. And there are also encouraging examples that social-ecological alternatives get policy and programmatic support, especially from municipalities and regional states. The struggle about social-ecological infrastructure, as well as its form and ownership, is central in reproducing or designing planetary and societal boundaries.

Radical social-ecological transformations would require putting in place socially sustainable degrowth strategies at multiple levels of governance in the global North, and various radical well-being

strategies in place of the development model in the global South. Degrowth has been depicted as an equitable and democratically-led selective downshifting of production and consumption levels that sustains human well-being, social justice, and ecological conditions, while reducing commodification and marketization of social life (Schneider, Kallis, and Martinez-Alier 2010; Sekulova et al. 2013; Jackson 2017; Chertkovskaya, Barca, and Paulsson 2019). Rooted in the 1970s limits to growth debates, the concept has vigorously emerged since the early 2000s in social movements and in academic and intellectual circles, and has emphasized the incompatibility between capitalism and ecological sustainability fueled by faith in eco-technology and market mechanisms. While deconstructing the growth ideology (Dale 2012; Schmelzer 2016), degrowth scholarship has focused both on the grassroots practices and social processes that embody values and interstitial strategies (Wright 2010), and on the institutions and state policies such as caps, green taxes, worktime reduction, or a basic and a maximum income that could progressively lead to a prosperous degrowth. Degrowth does not only challenge the material and ideological foundations of growth economies, but also questions the cultural infrastructure that justifies it (Muraca 2013; on important differences about degrowth, see Eversberg and Schmelzer 2018; Spash 2020). Social movements and projects operating in and around the degrowth mosaic of alternatives are creating spaces liberated from the dominant growth addiction, where experiments and experiences in alternative modes of living are not only possible, but become spaces of demonstration and possible amplification (Burkhart et al. 2020). Recent debates and strategy-building around degrowth also consider the state and its potential role in social-ecological transformation processes (D'Alisa and Kallis 2020; Koch 2020).

Conclusion: from planetary boundaries to social boundaries

The planetary boundaries framework is a powerful paradigm. What is does not and cannot address by design, however, is the dominant economic and political logics, power relations, and underlying interest structures as the main societal causes to boundaries being transgressed. In the most recent paper on planetary boundaries, the authors claim that "safe and just corridors for people and planet" will necessitate "an independent synthesis of broader social science literature" toward understanding causes of the problem, not just symptoms, but also grappling with issues related to diversity, governance, and ethics, to name but a few (Rockström, et al. 2021). This contribution is a first step in that direction. Research frameworks that combine such biophysical and critical social analysis, such as social-ecological economics, ecologically grounded political economy, political ecology, and social ecology, are a prerequisite to a more comprehensive picture of the key causal mechanisms inherent in capitalist societies that are responsible for far-reaching changes in the biophysical environment that have occurred since the Industrial Revolution. An initial task of such a framework would be to commonly develop a better understanding of the interrelations and interactions of biophysical and societal structures and processes, to overcome the disciplinary constraints within the sustainability research community, and, therefore, to challenge the downplaying or incomprehension of dangers associated with pandering to or naively trusting current decision makers and power-holders.

We have made arguments for a far-reaching social-ecological transformation. This would include a new order of knowledge that balances the relationship between natural sciences, on one hand, and social sciences and humanities, on the other – one that is both interdisciplinary and transdisciplinary at its core. In the spirit of epistemological pluralism, we thus call for a dialogue between natural sciences and social sciences and the humanities, between so-called "modern" forms of knowledge and "traditional" ones, but also between scientific and "non-canonized" knowledge, toward understanding and defining the conditions and thresholds in complex social-ecological system dynamics, as in our call for societal boundaries. This has implications for the very organization of scientific research and dialogue. No one discipline or approach is afforded the luxury anymore of pretending that its findings are not political, that one's responsibility as a researcher ends at the "boundaries" of a specific discipline or academic sphere. By saying that work should be transdisciplinary, we are calling for cross-cutting debate and confrontation and possible merging of knowledges and ways forward. We envision a process that includes a constructive critique of the planetary boundaries concept that is rooted in the definition of societal boundaries, or a common work toward "social-ecological boundary settings." The collaboration across disciplines and with different forms of knowledge is essential: boundary settings, as well as strategies for and practices of self-limitation, need permanent (scientific and practical) evaluation of the often unintended destructive effects and tradeoffs of particular strategies and practices.

We claim that societal boundaries are necessary for coping with the deepening ecological crisis and its devastating socioeconomic impacts – especially

for those who already live under precarious conditions and whose voices are not generally heard in the halls of decision making. With the notion of societal boundaries, we bring together procedural questions, as discussed above, with an explicit recognition of the need for self-limitation at the collective level or, in other words, of freedom *as* autonomy – autonomy not defined as independency but as ability for self-determination. By drawing on the work of Karl Polanyi, we claim that collective self-limitation is the condition for achieving not only justice, but also "freedom not only for the few, but for all" (Polanyi 2001 [1944], 265) – freedom rooted in taking responsibility for the social (and environmental) impacts of actions on others. The pursuit of collective freedom is central to the notion of "societal boundaries," as a terrain where different worldviews and understandings of current problems and social-ecological transformations can be negotiated.[22]

This idea of freedom involves organizing societies and their social metabolism in a way that its members do not have to live at the expense of others. It also invites us to acknowledge that, historically, societies always established limits in different forms. The practice and long-standing patterns of commoning that endure, despite the continuing push for dispossession, illustrates this poignantly. The illusion of "no limits" and "winners take it all" is quite new, bolstered by the capitalist mode of production and living. They were worked into the capitalist imaginary as a counterpart to the economic concept of scarcity rooted in the Spencerian social Darwinist version of evolution that sustains economic thinking since the nineteenth century.[23] Accordingly, in a world of scarce resources, the fittest are to survive, while the rest may either serve or not survive at all. Instead of collective self-limitation as an exercise of social freedom, freedom for the few takes the form of the imperial mode of living (or living at the expense of others) (Brand and Wissen 2021) through expansion (colonialism, neoextractivism), exploitation of cheap production factors (enslaved, exploited, and precarized labor), intensification of productivity, and externalization of consequences (waste, destruction of subsistence-based communities) onto subaltern social groups or onto the future.

At the same time, we acknowledge that capitalist relations are never "total" but remain contested. Other forms of societal organization such as, for example, solidarity economies or some types of care and reproductive work, do exist in parallel, and in some ways constitute the submerged part of an "iceberg economy," or economic activities that are hidden from view and devalued, but nonetheless constitute the foundation of the so-called productive economy (Mies et al. 1998; Gibson-Graham 2019). They are not necessarily independent from the capitalist economy, nor are they per se "sustainable," but they have other principles of functioning and value practices that are alternative to the hegemonic profit-oriented ones. In the global North as well as the global South, these other forms of living together are increasingly under threat as people and communities are firmly nudged or violently coerced into entering the capitalist mode of production and living. Ecological distribution conflicts and social-ecological movements are increasingly rising in resistance to the escalating global social metabolism and its devastating impacts: expansion of commodity frontiers, commodification of nature and space, and neoliberal/austerity governance (Muradian, Walter, and Martinez-Alier 2012; Temper et al. 2018; Calvário, Velegrakis, and Kaika 2017). Alliances among various social movements, groups, practices, and lived social experiments across the global North and the global South are already actively defending spaces for alternative ways of living together and securing the conditions for a "good life *for all*."

In a world of societal limits, the conditions for living a good life are defined through a collective process that accounts for sociopolitical struggles and hinge on the ability of others to do the same. In the societal boundaries concept, freedom as autonomy is ensured because of a just, deliberative process that leads to social and political rules that guarantee the substantial conditions for a good life for all. The liberation from the heteronomous, pervasive logic of unfettered expansion and acceleration sustains the individual and collective value of freedom as not having to live at the expense of others.

Notes

1. While social metabolism mostly refers to the stocks and flows of matter and energy that characterize a society or a type of society (e.g., the social metabolism of industrial capitalism based on fossil fuels is radically different from that of feudal societies), the concept of societal relations to nature expands the perspective to include flows of information and meaning – that is the symbolic dimensions – in interactions between what is historically (and contingently) seen as "society" and as "nature," and how such relations are embodied in institutions and practices (Hummel et al. 2017).
2. As explained later in this article, the logic is heteronomous (as a rule imposed from the outside) insofar as it operates as a functional rationality that regulates conduct and is not subject to deliberation.
3. By deep democratic process we mean more than formal democracy. Such a process would lead to a democratization of societal relations to nature and a democratization of the economy, thus supporting substantial participation and responsibility of all

societal members in framing and sustaining the conditions of living in common.

4. These include climate change, ocean acidification, stratospheric ozone depletion, nitrogen and phosphorus cycles, global freshwater use, change in land use, biodiversity loss, atmospheric aerosol loading, and chemical pollution (Rockström et al. 2009a, 472).
5. Biermann and Kim (2020, 513) list additional reasons for the success of the concept, but they also see little support for it from political actors in the global South as they refer more to the target-setting bodies of existing treaties such as the Intergovernmental Panel on Climate Change.
6. See a critique from an Earth-systems governance perspective in the comprehensive review of Biermann and Kim (2020).
7. Anthropologist Arturo Escobar (1996, 70) laments that "[c]onventional approaches also fragment the culturally constructed spatiality represented in particular landscapes, precisely because they are blind to sociocultural dynamics."
8. One finds citations of Wilkinson and Pickett's book *The Spirit Level* and to an article by Raworth about "doughnut economics" in a paper co-authored by Steffen in 2013, yet these references are mobilized merely for the descriptive content. Social mechanisms and structures that produce inequality remain undiscussed, as if inequalities just "happen."
9. While biogeophysical system tipping points and thresholds are not sociopolitical constructs, they can only be verified in hindsight, meaning that predictions concerning the existence of these tipping points are also the product of social/human practice. Our argument aims to be realist while acknowledging that the views, theories, and conclusions of the natural sciences are informed by social relations of knowledge production.
10. For example, when waste becomes a valuable commodity to the point of crowding out motivations to reduce its production by individuals or businesses and to depoliticize waste production (Valenzuela and Böhm 2017; Moreau et al. 2017).
11. This does not exclude the fact that, from a metabolic perspective, technological lock-in also emerges from, and is reinforced by, the material properties of biophysical structures, in particular infrastructures which, once in place, favor certain processes of institutionalizations and hinder others. Yet the social existence of these structures in a capitalist economy depends largely on continued investment and expenditure in order to expand the capacity to exploit; social and material causalities are enmeshed one in other.
12. Of course, though we characterize contemporary societies as capitalist, we are aware that other forms of domination and power such as patriarchy, anthropocentrism, and statism coexist and thrive under capitalism without being reducible to its logic.
13. We are aware that there are different understandings of capitalism or capitalist societies. We present a very broad understanding which is most plausible to us. Other approaches to social sciences and humanities, for instance institutionalist theories, theories of psychological behavior, or economic incentives or modernization theory, explain the ecological crisis differently. Here we outline core insights from critical social science that might contribute to the debate on societal drivers of unsustainability that lead to the transgression of planetary boundaries.
14. By capital, we refer to an institutionalized social relation where money is invested in an economic process of commodity production to generate returns (Marx). In this process, the monetary form of capital is transformed through productive expenditure into other forms like human labor, machines and tools, material and energy inputs, rights to land, and nature. All these forms are mobilized toward the one end of generating a monetary surplus through the production of commodities (be they goods or services). Capital cannot be reduced to one of the forms it takes on during this process because they are all aspects of its metamorphosis during circulation (Harvey 2010). Accordingly, capital is neither saved money nor machines and inventory, nor is it reaped profits, but the overall process that unites these forms. A further characteristic of capital is the reinvestment of monetary surpluses, expanding thus the mass of value that must find profitable outlays. Accumulation thus refers to a dual process of an ever-expanding mass of value changing form during its circulation in the economy and to the imperative of profitable investment of surpluses which implies further growth. The accumulation of capital must thus not be confused with a growing stock of productive material artefacts and infrastructures, though these realities are related.
15. Relative-to-GDP measures are particularly pernicious because they naturalize the principle of GDP growth when growth itself should be problematized.
16. Earth-system functions operate like a *grundnorm* which translates roughly into a "basic standard" or a rationally incontrovertible principle, insofar as they provide "a basis for international environmental agreements because anthropogenic projects that do not respect planetary boundaries with respect to … any of the nine interacting components of the Earth System, will (ultimately) fail empirically" (Schmidt 2019, 728). The *grundnorm* is accordingly not derived from nature, but from how Earth-system science articulates human-Earth integration.
17. With substantial conditions we mean conditions that are not merely formal, but include objective (for example, material or economic), subjective (for example, psychological), and intersubjective (sociocultural) conditions for achieving a good life in the sense of a life worth of a human being, or a life that people have a good and defensible reason to value (Sen 2009; Muraca 2012). This conception leaves the space open for different specifications and understandings that may vary from community to community and across individuals. Collective self-limitation aims at ensuring the *real conditions* for the achievement of a good life for all. This might imply that the ways in which well-being is achieved for some people might have to change radically, as these conditions could, in the sense articulated by Martha Nussbaum, be hindering the possibility of others to achieve well-being as a moral entitlement.
18. For the *Environmental Justice Atlas*, see https://ejatlas.org.

19. See Spash (2020) for a discussion of Raworth's ambiguous relationship to degrowth.
20. The seven biophysical measures include four planetary boundary indicators (CO_2 emission, phosphorous, nitrogen, blue water), two footprint indicators (ecological footprint, material footprint) and eHANPP. The eleven social measures (compatible with the SDGs) include nine need satisfiers (nutrition, sanitation, income, access to energy, education, social support, equality, democratic quality, and employment) and two measures of human well-being (self-reported life satisfaction, healthy life expectancy). To empirically study "living well within limits," Brand-Correa and colleagues therefore suggest a mixed-methods approach which includes quantitative top-down and bottom-up methods as well as qualitative, participatory methods (consultations, workshops, focus groups) to examine satisfiers and well-being dimensions in communities (see e.g., Brand-Correa et al 2018).
21. Mercosur is the Spanish term for the Southern Common Market comprising several Latin American countries. The group was established in 1991 by the Treaty of Asunción and its full members are Argentina, Brazil, Paraguay, and Uruguay. Associate members are Bolivia, Chile, Colombia, Ecuador, Guyana, Peru, and Suriname. Venezuela was suspended in 2016.
22. Implementing the *conditions* for a good life for all implies regulations against transgressing of collectively determined societal boundaries, as we have articulated earlier in this article regarding consumption corridors. This requires political sanctioning and coercion against individual conception of a good life that hinder the achievement of conditions of a good life for all, but also entails progressive social movements and alternative projects, toward supporting sociocultural norms rooted in social justice considerations.
23. This refers to Herbert Spencer's rendering of Darwin's evolution theory as applied to social systems. It was Spencer who introduced the idea of "survival of the fittest" and of individual competition, whereas Darwin stressed the importance of "social instincts" and sympathy in human societies (see Dardot and Laval 2017).

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Appendix 1.

Some Alternatives and Conceptions of Well-Being as Alternatives to Development

Worldview	Brief Overview	Further Details
Buen vivir	Is an understanding of well-being emanated from Indigenous people's modes of living. It translates most accurately into "living in plenitude." Similar notions exist in most indigenous societies across the Americas. In Ecuador, it was introduced in the country's political constitution in 2008, and from then became a slogan for public policies rather synonymous to "development." To challenge this new meaning, Indigenous peoples in Ecuador have avoided using the Spanish term and shifted to the term in the Kichwa language, *sumak kawsay*.	Monica Chuji et al in K othari et al. (2019)
Kawsak Sacha	Means "living forest" in the Kichwa language. It is a worldview promoted by the Amazonian Kichwa people of Sarayaku in the Ecuadorian Amazon and refers to the rainforest as a conscious community of living beings, both material and spiritual, of which humans are only one part.	https://kawsaksacha.org/en/; Patricia Gualinga in Kothari et al. (2019)
Sentipensar	Is the process by which we put thought and feeling to work together. It is the fusion of two ways of perceiving and interpreting reality from both reflection and emotional impact, until they converge in one same act of knowledge and action. The term is born from those words expressed by the fishermen in San Benito Abad (Sucre) to the Colombian sociologist Orlando Fals Borda: "We act with the heart, but we also use the head, and when we combine the two things like this, we are sentipensantes."	Patricia Botero Gomez in Kothari et al. (2019)
Kametsa Asaike	Term loosely translates as "living well together in this place" and dervies from an indigenous philosophy for well-being originating in the Ashaninka people of the Peruvian Amazon. It stresses two essential aspects: that the well-being of an individual can be only possible through the well-being of the collective, which includes humans, other-than-humans, and the Earth as a whole; and that it comes from and feeds into deliberative practice, with all in the collective working at it.	Emily Caruso and Juan Pablo Sarmiento Barletti in Kothari et al. (2019)
Ubuntu	A southern African concept that denotes "humanness" encompassing both a state of being and a state of becoming. This stresses that the relational aspects of life are essential; a human is not an atomized individual, but part of multiple collectives and their inter-relationships, including those of the non-human. Ubuntu is derived from or related to multiple concepts and expressions found south of the Sahara, including Umuntungumuntungabanye Bantu ("we are, therefore I am") in the Zulu, Xhosa, Ndebele languages, Botho in Sotho-Tswana languages, and others.	Leslie Le Grange in Kothari et al. (2019)
Kyosei	Is a Japanese term for symbiosis, conviviality, or living together, referring to relations within humans (between the genders, various cultures, and so forth) and between humans and the rest of nature. Importantly, it does not aim to homogenize, but stresses equality and sustainability by respecting diversity and heterogeneity, including of cultures, ecologies, ways of being, and knowing.	Motoi Fuse in Kothari et al. (2019)
Hurai	Is part of the cosmology of the Tuva ethnic community in China. It roughly translates as "all the best things," and includes aspects such as good life, health, sustainability, love, respect, and sanctity. Placing nature and gods ahead of humans, it stresses that when they are happy, humans too will be happy, and therefore our actions must be oriented toward safeguarding the well-being of all. Hurai has assumed an important position in the cultural revival movement of the Tuva people.	Yuxin Hou in Kothari et al. (2019)
Swaraj	Is an ancient Indian concept, revived and popularized by Mahatma Gandhi. It roughly means "self-rule," and encompasses individual and	

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Worldview	Brief Overview	Further Details
	collective sovereignty, with a foundation of spiritual and ethical responsibility toward all. This means that the individual is embedded in collectives, and while acting freely, cannot undermine other people's ability to also act freely. A radical, direct democracy (very different from its western liberal form) is embedded in *swaraj*. In recent times, it has been expanded into the concepts of eco-*swaraj* and *prakritik* (natural) *swaraj* to emphasize that responsibility extends to all of nature.	Aseem Shrivastava and Ashish Kothari in Kothari et al. (2019)
Minobimaatisiiwin	Is a concept denoting "living a good life" or in a "total state of well-being," rooted in the Anishinaabe and Cree native North American worldviews. It emphasizes holism, with a foundation of respect toward and reciprocity with not only other humans but all animals, plants, rocks, water, spirits, celestial beings, ancestors, and future generations. For anyone to be healthy, all have to be healthy, and so mutual respect and care are crucial. In recent times, *minobimaatisiiwin* has become an important part of the revitalization of indigenous healing systems.	Deborah McGregor in Kothari et al. (2019)
Taoism	Originates from the Tao Indigenous people, inhabiting their home island Pongso no Tao located off the coast of Taiwan. It is built on an inextricably close link between the cycles of human activity and the cycles of natural seasons, the ocean, and all of marine and terrestrial life. It encompasses an ontology based on the trinity of language, culture, and biological diversity. Human activity is oriented by a complex and unique calendar combining lunar and solar cycles and of the seasonality of fish and other marine life.	Sutej Hugu in Kothari et al. (2019)
Ibadism	A little-known school within Islam and predating the Sunni-Shia divide, *Ibadism* is built on a foundation of egalitarian relationships, simplicity, sobriety, and independence that respects the needs and independence of others. Religious tolerance and ethnic plurality is stressed, and in some variants (such as Djerba Island of Tunisia), self-governing communities that are autonomous of the state. Currently *Ibadism* is followed in Oman and by sections of society in Libya, Algeria, Zanzibar, and Tunisia.	Mabrouka M'barek in Kothari et al. (2019)
Jineoloji	Is the philosophical and ideological basis for the Kurdish ecofeminist movement in the region between Turkey, Iran, Iraq, and Syria, which is attempting to create a demarcated area of peace, direct democracy, and well-being with ecological responsibility. "It is the science that studies women based on the identity of life-woman, nature-woman, social-nature-woman, the culture thus created, its reflection on historic society and the reasons, sources and outcomes of the transformation of institutions, structures and concepts stemming from the definition of women. We may also define *jineoloji* as life science, social science, meaning science democratic modernity science and free co-life science in addition to science of women."	http://jineoloji.org/en/