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NOTE AND COMMENT

Unveiling global sustainability boundaries: exploring inner dimensions of human critical determinants for sustainability

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Abstract

Greater global awareness and action to implement sustainable development are underway. However, global progress towards sustainability has been slow. Advancing towards some form of sustainability requires greater attention and analysis of the role played by the human inner world. While the scientific analytic tools have focused on external aspects, we present a scientific methodology to identify human critical determinants (HCDs) acquired during the human biological and cultural evolution, which, although crucial for survival, well-being, and economic prosperity, may also currently act as human sustainability boundaries (HSDs). These boundaries can be softened by personal transformations with the capability of spurring resonant institutional and governance transformations. This commentary examines how a definable set of interacting and interdependent HCD provides a complete and coherent explanation of why reaching sustainability is currently an elusive objective.

Keywords Sustainability · Evolutionary approach · Human critical determinants · Human sustainability boundaries

Introduction

Sustainability is a recent concept that emerged during the Great Acceleration (Steffen et al. 2015). The Brundtland report (WCED 1987) defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Rarely has a conceptual idea penetrated so deeply into a broad range of human activities and acquired more rapid and robust visibility. Sustainability has the capacity to influence governments, businesses, law, education, nongovernmental organizations, and public opinion worldwide (Blackburn 2007; Lozano and von Haartman 2018).

There is widespread scientific and political consensus about the need for social, economic, and environmental sustainability (WCED 1987). A seminal example of this consensus was the approval of the United Nations 2030 Agenda, with 17 Sustainable Development Goals (SDGs) in 2015. However, global progress towards sustainability, measured by the SDG targets, has been slow.

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Sustainability science advanced considerably since the germinal essay of Kates et al. (2001) as a field of science that creates knowledge about the fundamental character of interactions between nature and society. One of the core questions for sustainability science posed at that time was if scientifically meaningful "limits" or "boundaries" beyond which the nature–society systems suffer serious risks of degradation, could be defined. This question has been answered by the definition of a "safe and just" space situated between planetary boundaries essential for survival and social boundaries crucial for all livelihoods (Rockström et al. 2009, 2023; Raworth 2012; Richardson et al. 2023). Such frameworks play a crucial role in assessing humanity's departure from reaching sustainability and delineating the resulting dangers.

Komiyama and Takeuchi (2006) emphasized the need to address sustainability science through the lens of three systems—global, social and human—and the interactions between them. They attributed greater prominence to the social system that includes politics, economy, industry, technology, and the human system that includes security, lifestyle, health, values and norms. The two systems should ideally be linked by sustainable production and consumption. The global system involves climate, resources, energy and ecosystems. In all these approaches sustainability science has focused on the external world of those three systems. In other words, past and current literature has assessed and addressed unsustainability reflected in the external world. However, there is a second dimension for sustainability that deals with the role played by the human inner world that lies at the root of sustainability challenges. This second dimension of sustainability is driven by motivations, rewards, individual self-interest, emotions, thoughts, identities and beliefs (Ives et al. 2019). We argue that it is possible to develop a scientific methodology that opens this second dimension of sustainability to sustainability science. The way to unlock the methodology is to study and assess the compatibility between our biological and cultural evolution and the current quest for sustainability.

Discovering human boundaries towards sustainability

Is it possible to construct a scientific methodology to identify the human determinants acquired in the human biological and cultural evolution that, although very important for survival, well-being, and economic prosperity, may also currently act as impediments in the pursuit of sustainability? One perspective recognizes the absence of an accepted scientific methodology for obtaining sustainability. How would one identify through the subjective lens of human evolution interpretation and self-knowledge the human determinants that may frustrate sustainability? We note that science has successfully unravelled significant facets of the biological evolution of the *Homo genus* over the past 2.6 million years, leading to modern humans. This evolution was followed by a cultural evolution initiated by early symbolic behaviour (Scerri and Will 2023; Tylén et al. 2020). Anthropology, in turn, has comprehensively investigated aspects of *Homo sapiens*, encompassing biology, evolutionary history, societal features, and cultural dynamics from ancient times to the present day.

We present arguments supporting the feasibility and utility of identifying human critical determinants (HCDs) that may act as contemporary human sustainability boundaries (HSBs). Critical because they are decisive for reaching sustainability. "May act" because we believe that HSB boundaries can be softened by personal commitments capable of spurring institutional and governance transformations, rendering sustainability more accessible.

The research question is: what are the basic human evolutionary "backstory" reasons hindering sustainability, and how can we overcome them?

The methodology follows an inductive evolutionary approach based on in-depth analysis through multiple data sources and seeks to identify the smallest set of interacting and interdependent HCDs. This parsimony is defined by the condition that the HCD set is the minimum set capable of providing a complete and coherent explanation of why sustainability is currently proving to be an elusive objective.

The HCD set comprises two distinct sub-sets, each delineating the influence of different evolutionary features. The first sub-set, consisting of two determinants, is characterized by intrinsic biological attributes, predominantly observed at the individual level. The second sub-set, comprising four determinants, is characterized by social and cultural attributes at both individual and collective levels. These HCDs encapsulate fundamental and deeply ingrained biological, social, psychological, and cultural traits crucial to understanding resistance to sustainability.

Human critical determinants acting as human sustainability boundaries

The dopaminergic reward system (1)

The basic ganglia in the mammalian part of our brain are involved in normal motor, cognitive, and emotional functions, motivation, and the dopaminergic reward system (DRS) that fosters basic human motivations for specific actions. Such actions are driven by necessities, e.g., eating, reproducing, avoiding pain, and providing pleasure (Douglass et al. 2017; Farr et al. 2016; Baird et al. 2007), the need for endurance, e.g., acquiring social status, minimizing effort, and gleaning information (Utevsky and Platt 2014;

Salamone et al. 2018; Bohler 2022). Repeating the stimuli is the only way to lead the nerve cells to give more dopamine, thereby providing more pleasure. It is a neurochemical growth principle deep in the brain (Ripoll 2022). During the Holocene, humans were able to project this principle into social, agricultural, economic, financial, and technological society models (Bohler 2022). Limits to growth (Meadows and Randers 2012; Meadows et al. 1972), if they exist, represent a concept alien to the DRS growth principle. DRS, by itself, is not incompatible with unlimited global population growth and unlimited consumption growth, because it rewards the consumption of goods and services to the extent that they provide satisfaction or pleasure. It is a process optimized through the maximization of utility. Softening the HSB boundary mode of DRS requires the control of the unlimited growth functionality using the connectivity of the basic ganglia with the neocortex to develop further the practice of sustainable actions and habits.

Time discounting in intertemporal decisions (2)

Time discounting (TD) measures the greater value assigned to an immediate reward over the value assigned to the same reward postponed (Santos 2021; Hayden 2015; Kalenscher and Pennartz 2008). The devaluation caused by postponement time is called time discounting. A relatively high human time discount rate values the immediate and short-term gains more than medium- and long-term action. This is unfavorable for the pursuit of sustainability. Climate change provides an excellent example since choosing the social time discount rate to calculate the cost–benefit analysis of investing in mitigation is critical for preventing dangerous human interference in the climate system (Santos et al. 2022). The low value advocated in the Stern Review (Stern et al. 2006) favors a rapid energy transition that addresses intra and intergenerational concerns. Nordhaus favors a higher rate, because it ensures more robust economic growth in the short term (Goulder and Williams 2012; Nordhaus 2017). Learning and practising the appreciation of the medium and long terms, as recommended by "longtermism" (MacAskill 2022), is a way to soften the second boundary.

Human–nature Interconnectedness (3)

Human–nature interconnectedness (HNI) started to change when human cultural evolution became more conspicuous and rapid around 40,000 years BP. This process was accelerated by the agricultural and industrial revolutions and by urbanization (Miller 2005). Most of the world's population no longer depends directly on the natural environment and resources to survive and thrive. In most contemporary societies, the fact that nature, biodiversity, and ecosystem services have become abstract concepts has devalued HNI. This devaluation ignores our ecological dependence. It disregards the fact that the human-made economy depends entirely on nature's systems, processes, and resources, thereby turning HNI into an Human Sustainability Boundary (HSB). Developing and restoring the value of HNI is a pathway to sustainability (Barragan-Jason et al. 2022) that helps to soften its HSB potential.

Self-interest and utility (4)

Self-interest and utility (SIU) essentially regard altruism (Neusner and Chilton 2005), self-interest, selfishness, and egoism concepts that emerged and evolved deeply in modern history. Egoism is either descriptive or normative. The first case corresponds to the Hobbesian thesis of psychological egoism, that all human behaviors are motivated by self-interest. Hobbes claims that "of all voluntary acts, the object to every man is his own pleasure" (Hobbes 1651). Since the middle of the seventeenth century, the Hobbesian apology of self-interest set the scene for the development of utilitarianism (Bentham 1789; Mill 1863) and the economic theory of Smith (1776), leading later to the prominence of mainstream economics. Market failures of neoclassical economics that affect sustainability can theoretically be fixed by correcting all sources of failure. However, the success of these corrections is increasingly uncertain (Cassiers et al. 2018; Brand-Correa et al. 2022; Schoenmaker and Stegeman 2023). Until now, market corrections have been unable to achieve environmental sustainability and have failed to strengthen the tendency for efficient allocation of resources that provide higher levels of human well-being in ways that distribute wealth more equitably within and between countries. Utility satisfies our self-interest, because it "tends to produce benefit, advantage, pleasure, good, or happiness" (Bentham 1789), largely through material possessions. Utility maximization forms the core of neoclassical economics and is considered the best-developed formal theory of rationality (Simon 2000). It can be a pathway to consumerism. The success of global mainstream economics in providing strong economic growth, economic prosperity, well-being, and the good life, and in liberating hundreds of millions of people from extreme poverty, especially during the Great Acceleration, makes SIU an HCD. However, Self-interest and Utility is also potentially an HSB, because there is increasing evidence that it is difficult to make the dominant economic paradigm compatible with sustainability (Gopel 2016; Fioramonti et al. 2022). Softening the fourth HSB requires transformational changes at the personal, collective, and institutional levels with a stronger focus on equity and sufficiency instead of self-interest and utility.

Cooperation and free riding (5)

Cooperation and free riding (CFR) relates to the crucial human cooperation for sustainability. It involves the concepts of voluntary and conditional cooperation and free riding when humans seek to work together for the common good, particularly to provide greater social and economic equity and environmental sustainability. One finds voluntary co-operators, conditional co-operators, free riders, defectors, and rational egoists who exploit the benefits resulting from the contribution of co-operators to the common good (Burton-Chellew et al. 2016; Caleiro et al. 2019). Many people worldwide are sensitive to the risks of unsustainability and contribute voluntarily with their initiatives, actions, and resources to reduce these. However, others with the capacity to be co-operators for the common good are not so much involved or stand aside in the multidimensional effort to reach sustainability. They are tempted to free ride, because they write off the personal cost of unsustainability. In this function mode, Cooperation and free riding (CFR) becomes an HSB. It can be softened through processes that develop compassion, empathy, generosity, and the knowledge needed to promote voluntary cooperation for sustainability.

International geopolitical and geostrategic relations (6)

International geopolitical and geostrategic relations (IGGR) between countries, particularly between the major powers and their allies, is the sixth and the most complex HCD. Although fundamentally related to human cooperation and defection, it includes all dimensions of social bonding resulting from the defense by each sovereign state of its religious, cultural, historical, political, economic, and national identity and strategic interests, including energy and natural resources interests. The world is fragmented by a hierarchy defined mostly by military and economic power that includes all countries, with a small number playing leading roles. The strong dependence that sustainability has on the major powers' geopolitics increases the importance of IGGR's role. There is generally a certain measure of cooperation in IGGR, but non-cooperation is also possible. IGGR may become non-cooperative or degenerate into an economic and technological conflict due to geopolitical and security (Steinbock 2018). It can also descend into an international armed conflict, as we witness today. In all those non-cooperating modes, IGGR becomes an HSB. It is difficult to soften this HSB, because colliding sovereign geopolitical and geostrategic interests tend to prevail over all other individual or collective interests. However, the increasingly higher degree of interdependence between advanced, emerging, and developing economies created by a more populated, complex, interconnected, and globalized world may incite the will to act needed to defend "Our Common Future", as the concept of sustainability suggests.

Is it useful to rethink sustainability from within?

A methodological question is knowing to what extent this exercise is useful or not and why, how and for whom. One point of view is that it is supererogatory, because full priority should be given to implementing actions for creating new technologies, social structures, and governance systems that effectively promote social, economic, and environmental sustainability. In essence, we should concentrate on the worlds of external guiding phenomena, natural resources, economic markets, social structures, institutions, and governance. Furthermore, identifying the Human Critical Determinants (HCDs) that may act as Human Sustainability Boundaries (HSB) could encourage the deceptive perception that there are deep-seated human traits that make it difficult or even impossible to reach some form of sustainability.

The other point of view, followed here, is to defend that human self-knowledge develops and strengthens the inner resources needed to address sustainability challenges. Solving them requires transformations that are not only technological and political but also operate at a personal level. Ives et al. (2019) have also emphasized the importance of people's inner worlds' role in solving sustainability problems and expressed the opinion that "sustainability science must take inner life more seriously". Focusing on these HCDs and how they function might be a starting point for softening their role and action as HSBs. In other words, it is a way of becoming more mindful of our capacity to realize personal inner transformations that contribute to sustainability.

Furthermore, our sustainability-motivated actions and habits could inspire others to become self-aware and follow similar pathways. We are aware that softening HSBs at the personal level is insufficient to have a measurable positive impact on global sustainability. It is just the beginning of a process that must compete with robust contemporaneous social transformational processes to be a compelling narrative.

Softening human sustainability boundaries: bridging the gap between inner transformation and global impact

Identifying the Human Sustainability Boundaries (HSBs) contributes to the overarching goal of "Knowing ourselves" (Plato 1990). Knowing these boundaries and how they act, avenues for surmounting them can be explored,

thus facilitating the path towards sustainability. We believe that future research may address the following aspects:

1. How to learn to control and moderate ourselves to make the dopaminergic reward system more compatible with our sustainability goals?
2. How to engage more in intertemporal decisions regarding medium- and long-term sustainability issues?
3. How can we change our collective behaviour and value systems so that the essential role of human–nature relations for our well-being and sustainable economic prosperity is recognized and considered in our decisions and actions?
4. How to restrain self-interest, normative egoism, and utility maximization so that the economic system at the global level is enabled to promote the three dimensions of sustainability?
5. How can we engage more people to cooperate unconditionally to provide public goods, promote sustainability, and ensure equity, human rights, justice, and diverse forms of prosperity?
6. How can we cultivate the cooperation and interdependence between people of different nations and their sovereign countries and governments so that defending "Our Common Future" reaches the highest global priority?

We presented a new methodology that allows for the identification of six HCDs acquired during our biological and cultural evolution that may function as HSBs in the pathways for sustainability. These HCDs belong to the second dimension of sustainability, namely the human inner world dimension. Knowing the HSBs and how their action can be softened opens the way to extend sustainability science to the second dimension of sustainability. The present methodology can be applied to address specific sustainability challenges, such as climate change. Our work aims to highlight limitations, suggest future research directions, and foster critical thinking within sustainability science and political action.

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Data availability Data analyses, literature review, and figures generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Code availability No codes were used for the study and analyses.

Declarations

Conflict of interest The authors have declared no conflicts of interest in this article.

Ethical statement The Faculty of Science, University of Lisbon (FC-UL) approved the study protocol. More detail about the different stages of the research is available from the corresponding author on reasonable request.

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