Advanced Review

Human well-being and climate change mitigation

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Edited by Louis Lebel, Domain Editor, and Mike Hulme, Editor-in-Chief

Climate change mitigation research is fundamentally motivated by the preservation of human lives and the environmental conditions which enable them. However, the field has to date rather superficial in its appreciation of theoretical claims in well-being thought, with deep implications for the framing of mitigation priorities, policies, and research. Major strands of well-being thought are hedonic well-being—typically referred to as happiness or subjective well-being—and eudaimonic well-being, which includes theories of human needs, capabilities, and multidimensional poverty. Aspects of each can be found in political and procedural accounts such as the Sustainable Development Goals. Situating these concepts within the challenges of addressing climate change, the choice of approach is highly consequential for: (1) understanding inter- and intra-generational equity; (2) defining appropriate mitigation strategies; and (3) conceptualizing the socio-technical provisioning systems that convert biophysical resources into well-being outcomes. Eudaimonic approaches emphasize the importance of consumption thresholds, beyond which dimensions of well-being become satiated. Related strands of well-being and mitigation research suggest constraining consumption to within minimum and maximum consumption levels, inviting normative discussions on the social benefits, climate impacts, and political challenges associated with a given form of provisioning. The question of how current socio-technical provisioning systems can be shifted towards low-carbon, well-being enhancing forms constitutes a new frontier in mitigation research, involving not just technological change and economic incentives, but wide-ranging social, institutional, and cultural shifts.

How to cite this article:
WIREs Clim Change 2017, 8:e485. doi: 10.1002/wcc.485

INTRODUCTION

As a field motivated by the preservation of human lives and the environmental conditions which enable them, climate change mitigation research can benefit greatly from a more rigorous understanding and application of human well-being. Not least, a rigorous theory of well-being ought to be crucial to our understanding of how to reconcile a complete decarbonization of production processes with justice, equity, and poverty alleviation—widely accepted requirements of a low-carbon transformation.[1]

Much of the recent motivation behind well-being research stems from a dissatisfaction with the widespread use of gross domestic product (GDP) as a measure of social progress (and the utility theory it is founded upon), the limitations of which are by now

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

widely known.[2] However, questions of well-being have occupied intellectuals for far longer than the existence of modern economic accounting, and they will continue to be a highly contested area of debate. Since the elaboration of well-being concepts will heavily influence one's framing of climate change mitigation—including the value-based choices that inform appropriate policies and pathways—it is important to examine the theoretical claims underlying typical approaches. This is our first point in this paper, demonstrated by contrasting theories of hedonic and eudaimonic well-being, as well as the recently conceived sustainable development goals (SDGs).

A second emerging issue in well-being and climate change mitigation research is how to conceptualize and quantify the benefits that society derives from biophysical resource use. This is a complex and normative issue, for such benefits may be specific to individuals and communities, and are indirectly linked to biophysical resources through supply chains, physical infrastructures, and different forms of social provisioning. Research in functional specialisms around energy access, energy services, and food provisioning are filling the gaps in this chain of the biophysical to the social. Again, how this problem is approached is distinctly driven by the choice of well-being theory, suggesting that it deserves far greater attention within the mitigation literature. However, doing so would allow for a systematic analysis of provisioning systems, focusing on their benefits to society, impacts on the global carbon budget and potentials for deep decarbonization.

THEORIES OF WELL-BEING

'Human well-being' is complex and contested. It is often used interchangeably with 'happiness,' 'human development,' 'living standards,' 'quality of life' or 'welfare,' and has grown to become a catch-all term for measuring and promoting good lives and a good society. Researchers in the climate change field have tended to work with established frameworks, such as the capabilities concept [typically equated with the Human Development Index (HDI)] or politically endorsed measures such as the Millennium Development Goals (MDGs) or the SDGs. To engage in the debate as to how well-being can be operationalized, we draw upon two broad schools of thought: hedonic and eudaimonic well-being. We then contrast them with the SDG framework, which is not a carefully philosophized set of objectives, but an approach that will be more familiar to some readers. This overview is not intended to be a comprehensive categorization of well-being, which is far more nuanced than the space here allows,[3–5] but it serves to demonstrate that alternative starting points can lead to very different practical outcomes in the assessment of well-being and its implications for climate change mitigation.

Hedonic Well-Being

Hedonic well-being arises from the work of Epicurus (and later classical liberalists Mill and Bentham) in establishing a subjective state account of human motivation.[6] In this mental account of well-being, the good life is a matter of balancing pleasure over pain, enjoying life, and feeling good.[7] Hedonic well-being has gained influence in the field of psychology as the basis for assessments of 'subjective well-being': including happiness assessments, life satisfaction, and the presence of positive/negative mood.[8] It is now supported by standardized questions in large-scale data surveys, such as the World Values Survey, World Happiness Report and the UK-based National Labour Force Survey.[9–11] A typical question in these surveys is '*All things considered, how satisfied are you with your life as a whole these days? Please give a score of 0 to 10 where 0 means extremely dissatisfied and 10 means extremely satisfied.*'[12]

Hedonic accounts make several implicit theoretical claims. First, by relying upon self-assessments, they claim that individuals are best placed to understand and articulate their own desires; accordingly, hedonic well-being leans towards a postmodern, relativistic view of human motivation, rejecting a shared set of universal values or norms.[8] Second, hedonic well-being suggests that a good society is built upon individuals maximizing their own happiness, a position most closely associated with Bentham's utilitarianism.[7] Critics of the approach argue that subjective self-assessments often bear little relation to underlying levels of material deprivation (a phenomenon widely known as adaptive preferences), while appeals to hedonism generally have little to say about social aspects of well-being, such as an active political life, notions of justice, or a sense of inter-generational citizenship.[3,6,13,14]

Since hedonic well-being tends to measure overarching mental outcomes, psychological, economic and sociological research has delved into question of the underlying causes, or *determinants*, of happiness or life satisfaction. Identifying these determinants is vital for both policy relevance and more applied social or environmental science research. However, the range of different factors emphasized in each social science discipline, alongside methodological issues, make consensus on the determinants of hedonic well-being elusive. Psychological research tends to prioritize mental, biological and cognitive determinants,[15] economic research emphasizes

economic factors, such as income, consumption, and employment,[16] whereas sociological research considers the role of social (as well as economic) institutions, including healthcare provision, social capital, and political processes.[17]

The insights arising from well-being research are hence tempered by disciplinary perspectives. For sociological researchers, hedonic accounts are a subjective reflection of objective conditions; they bring deep insight into the wider state of society. Accordingly, the solution space is focused on collective rather than individual solutions.[18] For psychologists and economists, this perspective is recognized but tends to be marginalized in favor of individual solutions. Such is the case for the major authors of happiness research—Ruut Veenhoven and Richard Layard—who recommend addressing individual competencies, 'training art-of-living skills,' and cognitive behavior therapy as key solutions to societal well-being.[19,20] In this latter sense, hedonic assessments remain the subjective counterparts of GDP, interpreted as an objective assessment of utility maximization through aggregate individual expenditure.

The hedonic tradition has nevertheless been influential in sustainability research. The so-called Easterlin paradox, wherein self-reported life satisfaction has remained stable across a number of developed and developing countries despite decades of economic growth, was a key influence on the growth/degrowth debate of the 1980s.[21,22] It continues to support a claim that transitioning towards a low-consumption, zero-growth society would be consistent with stable or improved well-being.[23]

Eudaimonic Well-Being

Eudaimonia refers to a central concept of Aristotelian thought, that human well-being is derived from 'flourishing' and lies distinct from a state of happiness or pleasure. Aristotle argued that it is the actions, content and processes of an individual's life that matter, rather than transitory and subjective mental states.[24] Accordingly, eudaimonic accounts focus on the activities, abilities, or 'functionings' (rather than goods) that constitute a well-lived life. This philosophy has informed a wide range of well-being approaches, including the capabilities concept,[25–28] the multidimensional poverty index,[29] and theories of fundamental human needs.[30,31]

A central concern of eudaimonic well-being is the need to incorporate diverse intercultural views on what constitutes a good life (and so avoid claims of paternalism), but remain specific enough to measure and operationalize the theory in practice. For Sen[27,28] and Nussbaum,[25,26] this cross-cultural consensus emerges from identifying a set of fundamental 'capabilities' that allow one to live as they would choose, but to refrain from defining a particular form of good-living. Similarly, Max-Neef[31] and Doyal and Gough[32] argue that a core set of objective and universal human needs can be defined, even if the particular ways in which we satisfy these needs (known as 'satisfiers') remain open to personal and cultural preferences. Contemporary accounts of eudaimonic well-being thus share Rawls' view that despite the differing interests of individuals and communities, including how they might choose to pursue their lives, society can still converge on a set of key social institutions to which all are entitled universal access.[3]

A commonality among eudaimonic approaches is the multidimensionality of human well-being (Table 1). These dimensions incorporate both physical and social needs, and psychological aspects, but differ across accounts according to the literatures they were derived from. Dimensions of eudaimonic well-being are usually not ordered in a hierarchy (although individuals may emphasize some dimensions over others); nor can they be substituted or reduced to a smaller set (education will not compensate for lack of nutrition). These nonsubstitutable dimensions of well-being have also been called ultimate 'reasons for action,' for which no further reason is needed.[4,33] Importantly, from the perspective of climate change mitigation, they include both enabling components (such as access to modern energy services) and protections from negative influences (such as air pollution or climate change impacts), also known as positive and negative freedoms.[32] Of course, operationalizing these diverse categories into indicators is a challenge. To do so, it requires extensive data that cannot be meaningfully compared or aggregated, and often includes dimensions that cannot be quantified (such as Nussbaum's 'Emotions' and 'Play' or Max-Neef's 'Affection'). These issues generally hinder the straightforward policy assessment of eudaimonic well-being.[34] Deficit-oriented approaches, that is, the identification and elimination of meaningful barriers to physical health and social participation, are simpler to operationalise.[32]

For many eudaimonists, notably Nussbaum, Max-Neef, and Doyal and Gough, these are politically grounded projects. By explicitly defining that which is necessary for a flourishing life, eudaimonic accounts provide the philosophical underpinning to a basic social minimum that should be guaranteed by constitutional right. This perspective informs many ethical debates surrounding climate change, including

TABLE 1 | Dimensions of Human Well-Being from Selected Eudaimonic Approaches, Organized by Common Themes (Not Exact Equivalents)

Nussbaum Central Human Capabilities	Max-Neef Axiological Categories of Human Need	Doyal and Gough Theory of Human Need	The Sustainable Development Goals
Life Bodily health		Physical health (BN) Appropriate health care (IN) Safe birth control/childbearing (IN)	3. Good health and well-being 5. Gender equality
	Subsistence	Adequate food/water (IN)	2. Zero hunger
Bodily integrity Control over one's environment	Protection	Protective housing (IN) Safe physical environment (IN) Safe work environment (IN) Physical security (IN) Security in childhood (IN)	6. Clean water and sanitation 7. Affordable and clean energy 16. Peace, justice and strong institutions
		Economic security (IN) Non-hazardous work environment (IN)	1. No poverty 5. Gender equality 8. Decent work and economic growth
Senses, thought, imagination Emotions	Creation	Mental health (BN) Cultural understanding (BN)	3. Good health and well-being
Practical reason	Understanding Identity	Cognitive understanding (BN) Appropriate education (IN)	4. Quality education
Affiliation	Participation Affection	Opportunities to participate (BN) Significant primary relationships (IN)	5. Gender equality
Play	Leisure Freedom	Critical autonomy (BN)	16. Peace, justice, and strong institutions
Other species		Sustainability preconditions	14. Life below water 15. Life on land 13. Climate action
	Satisfiers	Societal preconditions for need satisfaction (means, not ends)	9. Industry, innovation, and infrastructure 10. Reduced inequalities 11. Sustainable cities and communities 12. Responsible consumption and production 17. Partnerships for the goals

BN, basic needs; IN, intermediate needs.

discussions of fair mitigation burdens that provide adequate room for development.[35–38]

Political and Procedural Accounts

A third category of well-being accounts are those goals, targets, and indicators that are not based on carefully philosophized theory, but are politically endorsed measures generated via democratic or procedural means. The SDGs are such an example, comprising 17 overarching goals and 169 indicators agreed upon at the United Nations in 2015.[39] The SDGs and their antecedent MDGs are important in setting the international stage for binding human rights and poverty eradication targets.[40]

The SDGs follow the broad thrust of eudaimonic accounts: they are multidimensional, nonsubstitutable, and converge on a similar basic set of requirements such as adequate nutrition, healthcare, and education. They also include wider social aspects of well-being that are emphasized by eudaimonists, such as gender and economic inequality, and democratic and transparent institutions. Table 1 contrasts

three eudaimonic lists with the SDGs, showing common themes and considerable overlap, although exact equivalence is hampered by a focus on ends in the former (goals sought only for themselves) versus the mean-focus of many SDGs (goals that enable other goals). Indeed, critics argue that the SDGs are too broad in scope, resulting in a complex mixture of means, ends, goals that potentially compete or interact with one another, and goals that are not strictly related to well-being.[41,42] Much controversy and discussion has focused on, for example, the suitability of Goal 8: 'Decent work and economic growth.'[43,44]

The lack of clear theorizing around the SDGs brings further problems: without an accompanying set of values and aims, how are trade-offs between goals going to be managed?[45] And how would a priority structure for implementation be defined?[42] The 2030 Agenda for Sustainable Development is not a constitutional document and provides no guidance on these more normative questions nor is it situated within a body of literature on justice, ethics, and empirical research on human needs and attributes (as the eudaimonic accounts claim to be). This also entails risks from a research perspective. The enormous scope of the SDGs allows one to simply choose goals and their indicators based on expedience and available data, effectively prioritizing research on quantitative and measurable dimensions of well-being, while disregarding questions of power and conflict that often lie at the heart of poverty and development.[44–46] In other words, the goals are non-substitutable in theory but not in practice. An interesting question is whether philosophized well-being accounts provide a template for dealing with these issues, that is, by rigorously defending a particular priority scheme or addressing distributional conflicts.

From Well-Being Theory to Climate Change Research

This brief summary highlights the important differences between commonly applied well-being concepts. Whereas hedonic research is typically grounded in subjective and adaptive self-assessments, eudaimonic research and the SDGs are founded on objective and universal conditions. The tendency towards an individualistic framing of well-being in hedonic accounts also contrasts with a more social emphasis in the eudaimonic accounts. Yet these differing approaches can also be seen as complementary, capturing different aspects of a well-being concept that cannot be reduced to a single disciplinary paradigm.[5] Subjective well-being research is primarily descriptive, an evaluation of people's self-observed state-of-being; whereas eudaimonic accounts are more prescriptive and concern how people should be treated.[47] Outcomes in the latter are almost certainly relevant for the former.[6]

However, as a basis for framing issues in climate change mitigation and policy, the choice of approach is consequential and strongly favors eudaimonic well-being. For instance, well-being concepts are highly pertinent to questions of inter-generational justice, including the equalization of life prospects between current and future generations—a major topic of climate justice and ethics.[48] In this context, intra- and inter-generational resource equality issues ought to be grounded in the eudaimonic approach, since the subjective and adaptive nature of hedonic self-assessments render them ill-suited to the task of measuring and conceptualizing the well-being of other cultures and future generations.[38] Accordingly, climate change impact research focuses on the external and objective conditions underpinning well-being, such as nutrition via crop yield decline, or the impact on human health of shifting disease vectors.[49]

The choice of theory also frames which strategies are best-suited to mitigating greenhouse gas (GHG) emissions. A narrow hedonic focus on the subjective well-being of individuals invites solutions that target behavior and choice, that is, by educating wealthy people to consume less, or poor people to better cope with climate impacts (i.e., adaptation).[38,50] In contrast, eudaimonists see individual behaviors and choices as originating within social and political contexts, evoking a long-running theme of structure versus agency in social theory. They call for institutional change as a necessary prerequisite to behavioral change, arguing that the 'individualization' of environmental solutions is both ineffective and counterproductive.[50–53] These two points—the link to equity and justice, and individual versus social change—are particularly relevant for understanding how eudaimonic well-being research is driving new and important directions in the field of climate change mitigation.

WELL-BEING AND CLIMATE CHANGE MITIGATION RESEARCH

The current paradigm of climate change mitigation research coalesces around temperature targets and their associated cumulative emissions budget constraints.[54,55] The Paris Agreement reinstated these targets as the principal goal of climate policy, with the ambition to hold temperatures to 2°C above preindustrial, while 'pursuing efforts' towards a lower 1.5°C threshold.[56] However, the applicability, feasibility, and depth of transformational changes required to meet them are currently the subject of much commentary and

research.[57,58] Well-being research has an important role in this discourse, as concepts of human need and quality of life naturally overlap with the everyday uses of energy and resources within society—the 'demand-side' of climate mitigation, an area that is perceived as neglected in the field.[59–61] A stronger emphasis on demand-side mitigation would also reduce dependence on the long-term deployment of uncertain and controversial carbon dioxide removal technologies.[62]

But despite the apparent importance of well-being in this context (and in the aforementioned context of equity), it has received relatively little attention in comparison to the economic and technical features of mitigation—particularly within the latest IPCC 5th Assessment (where well-being was only substantively addressed in chapters 3 and 4 of the Working Group III Report). This bias can be seen across the entire climate change literature using a comparative keyword search for income and well-being (Table 2). As of the end of 2016, we identify only 100 studies that refer to well-being in the context of climate change mitigation, in comparison to 1306 for income. Within the 100 studies, a very broad array of topics can be found. These include: well-being in the context of cities, particularly with reference to thermal comfort, noise pollution and 'quality of life' (18 papers); well-being and ecosystem services (13); the links between energy consumption and indicators such as life expectancy and the HDI (11); human health in the context of air pollution (9); and different aspects of transportation needs and provisioning (8). Often, well-being is mentioned only within the problem framing and does not constitute the actual subject of study. These complications generally confound a systematic review of the well-being literature, and add to the problematic task of following and gaining insights from a research base that is exponentially growing.[63]

TABLE 2 | Web of Science (WOS) Search Query for Well-Being and Climate Change Publications, 1900–2016

	Well-Being (1)	Income (2)
Climate change (3)	848	6803
Climate change (3) and mitigation (4)	100	1306

Search terms are as follows: (1) well*being OR 'human development' OR 'happiness' OR 'quality of life'; OR 'basic need*'; (2) income OR 'economic growth' OR GDP OR welfare; (3) 'climat* chang*' OR 'global warm*' OR 'carbon emission*' OR 'CO(2) emission*' OR 'energy consumption'; (4) mitigation OR decarboni*ation OR (emission* NEAR/3 reduction*). Intersecting rows/columns are combined with an AND operator, *'s indicate a wildcard to capture different spellings, the search is performed using the WOS topic query that indexes the abstracts, titles and keywords of all document types.

In the following section, we focus on two major strands of well-being and climate change mitigation research. The first of these investigates the empirical evidence linking GHG-emitting activities, the energy and material provisioning of societies (provisioning systems), and well-being outcomes. A second strand of literature focuses on the normative aspects of climate change mitigation that are exposed by well-being concepts, specifically through discussions of minimum provisioning levels and upper consumption limits.

Empirical Evidence Linking Well-Being and Emissions

The two most fundamental links between GHG emissions and well-being are through agriculture and energy consumption. Agriculture is the primary driver for the principal non-CO_2 GHG emissions, such as methane and nitrous oxides, and is also important in land-use change; whereas energy use is the main source of CO_2 emissions. The link between agriculture and well-being is obviously through food supply, while energy contributions to well-being can be more nebulous to define and measure, due to energy's multiple direct and indirect uses. Energy is used within households for heating, cooling, lighting, cleaning, cooking, and food preservation. It is also necessary in connecting households to the world beyond, through transport and communication. Moreover, energy is embodied in all goods and services consumed, including vital public services such as sanitation, health, and education.[64,65]

As a result of this complexity and ensuing data challenges, many empirical studies linking energy and well-being limit themselves to national or regional averages of consumption. One of the earliest such studies was Mazur and Rosa's *Science* article 'Energy and Life-Style.'[66] In it they presented correlations between a number of social indicators (such as health, education, and subjective well-being) and per capita energy consumption for several dozen nations; arguing that at low levels, increasing energy consumption is highly correlated with a good 'life-style,' but at high levels, it is not: in other words, a nonlinear relationship of steeply diminishing returns. This basic international functional relationship holds for a variety of well-being indicators and energy or emissions impacts.[67–75] These results are confirmed at the intranational (individual or household) level in small-scale studies considering the relationship between subjective well-being and emissions in Canada and Sweden.[76,77] Similar results have also been found in comparing the ecological footprint and subjective

well-being, for instance, through the Happy Planet Index and a stream of literature known as the 'environmental efficiency of well-being.'[78,79]

The nonlinearity of well-being and energy consumption is evidence of the satiability emphasized in some eudaimonic accounts, particularly the human needs approaches.[80] If a dimension of well-being is satiable, such as adequate nutrition or a protective environment (housing), then, once it is satisfied to a sufficient level, no further gains in that particular dimension are possible. This of course raises the problem of identifying thresholds of sufficient energy consumption, a complex normative issue—what conditions constitute 'decent' living standards?—that typically results in setting arbitrary values of a given well-being indicator (e.g., greater than 0.8 on the HDI scale).[36] Studies converge on a final energy consumption requirement of 30–40 GJ per capita energy as a minimum threshold approximating a good standard of living (e.g., above 70 years life expectancy, full access to water, sanitation, electricity and other basic infrastructures).[69,70,81] This minimum sufficiency threshold is also observed to shift downwards over time.[68,70]

A large literature exists linking individual, household or income class consumption to direct and indirect energy use or emissions, usually using environmentally extended input–output frameworks.[82–84] However, most of these studies simply consider the environmental implications of consumption, without extending the analysis to well-being (although consumption can be considered synonymous with well-being from a neoclassical economic perspective, as discussed above, a more comprehensive approach encompassing multiple dimensions of well-being is better-suited to sustainability studies[85]). A notable exception is the stream of work focused on minimum energy use and energy access in relation to poverty alleviation in India and South Asia,[64,86–91] and Brazil.[75] Here it is argued that poverty alleviation requires not only a certain quantity of energy, but also that the type and quality of energy that is provisioned matters.[64] Accordingly, substituting traditional biomass-based cooking fuels for modern and clean energy vectors (e.g., kerosene and electricity) has fairly minimal GHG implications, but significant attendant benefits for reducing indoor air pollution and its associated health burdens.[87] The health burdens of air pollution in general are often considered under the co-benefit strand of climate change mitigation research.[92,93]

In wealthier countries too, such as the UK and Finland, some studies have used household surveys, expenditure data, and workshop deliberations as the basis for discussions around which consumption activities are clearly linked to human need satisfaction, and which could be reduced, eliminated, or shifted towards less intensive forms as part of a mitigation strategy.[94–96] Finally, the emission effects of reducing inequality in the UK and its additional effects on social outcomes have been considered.[97] Arguably, these bottom-up perspectives provide a greater opportunity for open and normative deliberations around sufficient energy consumption in different contexts and its effects on social outcomes.[36]

The emissions implications of agricultural production for sufficient food consumption have been explored comprehensively, at a global scale. Several recent papers have considered the emissions associated with food consumption levels and changes in diet.[98–100] Others have emphasized the limits of climate change mitigation proposals arising from the land use required for food production.[101,102] Both Hedenus et al. and Bajželj et al., using different methodologies and scenarios, conclude that agricultural emissions can be expected to account for close to the entire projected budget for remaining within 2°C, whereas stringent diet changes and food demand management could bring the total down to roughly half of this.[98,99] Clear sufficiency thresholds define the relationship between food supply and well-being; humans have minimum (and maximum) calorific intakes to sustain. The relative lack of mitigation scenarios that incorporate global food production and land-use change should therefore be a cause for concern—particularly since food provisioning systems are one of the most inflexible sectors to mitigate.[99]

Normative Aspects of Well-Being and Climate Change Mitigation Research

Besides the empirical task of linking well-being to emissions, well-being concepts are a rich source of inspiration for examining normative issues in climate change mitigation, including the appropriate design of mitigation policies that ensure minimum adverse effects on human livelihoods. An important and recurring topic in this context is the role of consumption in shaping well-being outcomes, while also inducing global GHG emissions. This has several related aspects: Does increasing consumption lead to progressively higher levels of well-being? What results in terms of well-being from deficiencies in consumption? Furthermore, how is the provisioning of well-being conceptualized across different approaches? And what does this suggest for shifting towards a low-carbon society? These theoretical claims and their links to climate change mitigation research are summarized in Figure 1 and discussed below for a

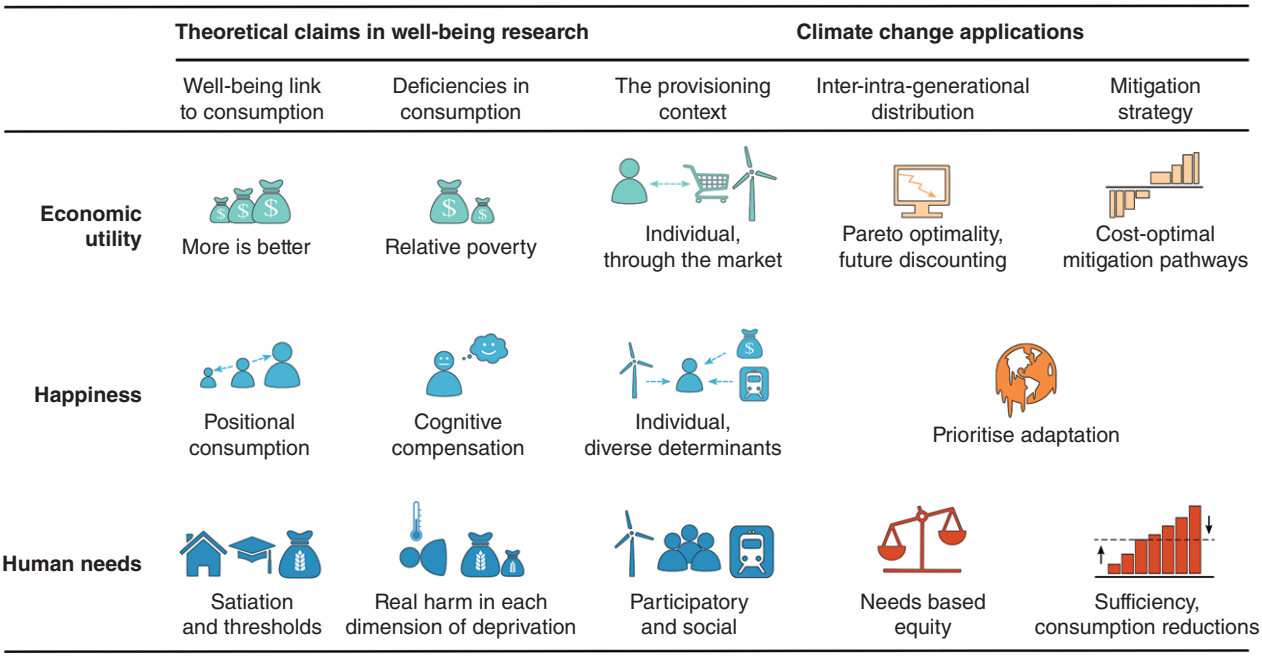

FIGURE 1 | The relevance of well-being theory for climate change research and policy. Unlike hedonic and utility-based approaches, human needs theory argues that vital dimensions of well-being correlate with consumption, but only up to a threshold. This implies a mitigation strategy that protects minimum levels of consumption but critically analyses excessive consumption. In addition, the provisioning context of human needs is seen as participatory, where transformative mitigation potential can be found in social as well as technological change.

selection of well-being approaches—contrasting the classical economic approach to welfare measurement (utility) with a hedonic (happiness) and a eudaimonic (human needs) approach.

Upper Limits to Consumption

Consumption—the acquisition and use of commodities and services which rely on biophysical resources—is represented in mainstream economic thought as an expression of preferences through purchases in the marketplace. According to the classical axiom of maximizing utility, more consumption implies more satisfied preferences, hence higher well-being. By contrast, consumption is often not seen as an intrinsically fulfilling activity in the happiness literature, but as an intensely competitive means to acquire social status and scarce goods.[103,104] One's position in the hierarchy of wealth is therefore a major determinant of individual well-being.[105] In human needs theories, consumption has only a limited role: it is necessary to satisfy distinct domains of material need (such as shelter, nutrition, education), but since these needs are satiable, exceeding a threshold of consumption is both unnecessary and potentially counterproductive.[32,106]

That well-being theory may in itself provide a reason for de-incentivizing consumption—either because it is revealed as a zero-sum positional game (empirical happiness research), or because it delivers highly diminishing returns beyond thresholds of material need satisfaction (human needs theory)—has been taken as a standard argument in various anti-growth literatures,[6,21,23] and even advocated as policy by the UK opposition leader Jeremy Corbyn.[107] Yet, while researchers often shy away from the difficult normative discussion of limiting the GHG emitting activities of individuals and collectives to an upper level,[108] these suggestions do frequently appear on the 'supply-side' of biophysical resources, most famously in the planetary boundaries concept,[109] or the 2°C goal of the Paris Agreement, which can be associated with a strict and limited budget of emissions.[54] From an inter- and intra-generational justice perspective, this issue is of central importance, particularly where high-emitting activities constitute a limitation on the life chances of other individuals—as is the case where basic 'subsistence emissions' come into competition with 'luxury emissions' within a finite carbon budget space.[37] Indeed, where one's consumption activities meaningfully constrain the freedom of others, setting upper boundaries is supportable even from a liberalist perspective.[110]

The basic premise that follows from this discussion is that consumption should not be taken as a neutral given, nor should all types of consumption be treated equally in climate change mitigation research.

Rather, consuming activities can be distinguished based on how much they contribute to human well-being. This is easier to conceive of at the extremes: the aggregate well-being benefits associated with food consumption are qualitatively different from those associated with international aviation for leisure. If demand reduction becomes a necessary accompaniment to decarbonization (as suggested by current budget and pathway constraints), then the priority structure for enforcing mitigation in these hard-to-treat sectors is evident—however, so is the political challenge of implementing well-being based emission priorities, given the prevailing consumption patterns and interests of powerful elites.[111]

A further challenge in this line of research is how to compare the marginal differences in well-being benefits derived from different patterns of consumption, such as alternative local transportation options.[112] Applications of Max-Neef's participatory human-scale development framework open up the analytical space for such work by enabling researchers to characterize how communities currently satisfy their needs, to identify 'social pathologies' and forms of satisfaction that undermine well-being,[23] and to explore alternative satisfiers that meet local needs within biophysical constraints.[113,114] Yet these local approaches can only be accompanied by wide range of social changes to overcome consumerism, including shorter working hours, community or social initiatives, or even reforms to the monetary system.[115] But since national and international distributions of emissions are marked by enormous disparities,[116–118] the potential for such cultural and institutional shifts to lead to rapid and deep decarbonization through energy demand reduction (simply put: less consumption) is seen as one reason why the narrow focus of contemporary mitigation research on techno-economic issues is misleading.[61]

Minimum Consumption

Deficiencies in consumption—the loss of access to vital commodities and services—are treated in economic theory as one-dimensional income poverty, often masked by aggregate growth in the economy. Nor are happiness indicators seen as a reliable guide to assessing consumption deficiency, as empirical research shows remarkable psychological adaptations to deprivation (the 'adaptive preferences' previously discussed).[13,119] In contrast, human needs theorists are unequivocal. Deficiencies in consumption result in real harm in each dimension of deprivation: the loss of access to healthcare, adequate nutrition, or employment have clear consequences for physical health and social participation. Hence, a clear goal arising from eudaimonic accounts is to establish minimum level of consumption provisioning. Rawls' primary goods are a notable example.[120]

Minimum provisioning proposals have been a consistent and important strand of literature in the mitigation literature on inter- and intra-generational equity. They differ from traditional lists of basic goods and social needs by outlining the resource and energy requirements required for their satisfaction, in turn calling for the safeguarding of these biophysical resources within a continuously dwindling carbon budget space. This is the essential principle of Shue's 'Subsistence Emissions,'[37] Baer's 'Greenhouse Development Rights,'[35,121] Rao and Baer's 'Decent Living Emissions,'[36,122] and Raworth's 'Safe and Just Operating Space.'[123] Elaborating on a minimum set of provisions and their resource requirements (direct and indirect) is of course complex, entailing manifold scientific, ethical, political, and normative risks. These proposals therefore often emphasize the importance of bottom-up procedurally generated knowledge, bringing together scientific experts, local participants, stakeholders, and policy makers—a process outlined by Doyal and Gough,[32] and well-developed by Storms et al. for minimum standard of living 'reference budgets' across the EU.[124] This process must be reflexive enough to allow for specific or changing local circumstances, since different communities and countries may have widely varying socio-technical provisioning systems in place, with ensuing variations in terms of emission levels and mitigation options.

Within the climate and development literature, a basic set of infrastructures—household electricity access, water and sanitation facilities, adequate nourishment, and healthcare—have been identified as essential components of minimum provisioning.[71,125] There is therefore a growing body of work investigating the GHG emissions associated with the construction, maintenance, and end-use of these infrastructures,[70,71,86,126] including alternative, decentralized forms that offer the same essential services at a lower cost of emissions[91] as well as innovative funding mechanisms that could recycle climate mitigation revenues for their construction and provisioning.[127] Interestingly, the efficiency (in energy consumption and emissions terms) at which countries establish these infrastructures varies significantly; an issue that has not been substantively explored so far.[70] However it is evident that the macro-trend of increased fossil-fuel reliance in the global south will almost certainly lock-in carbon intensive forms of minimum provisioning.[70,128] This has significant distributional implications for the global carbon budget, most substantively addressed in the Greenhouse Development

Rights framework.[35] It also points a long-running theme in climate change research, namely the trade-offs between emissions mitigation and national development ambitions.[129,130]

The concept of minimum provisioning is also broadly applicable to modeling and scenario analysis, including integrated assessment models (IAMs), which are purposed towards analyzing multidimensional trade-offs between mitigation and social objectives (typically in an economic framework). Past work has expressed uncertainties about the extent to which IAMs ensure minimum provisioning in per capita energy consumption,[126] so it is important to note the current centrality of 'human development' in the shared socio-economic pathways (SSPs), the new generation of baseline scenarios for coordinating IAM research. These now include education, health, infrastructure, equity and social features, and baseline per capita energy consumption levels of 30 GJ in all regions.[131,132] There is increasing attention paid in the modeling literature to the trade-offs between land-based mitigation (bioenergy), food production, and water scarcity—with, as previously mentioned, tight margins for achieving these multiple objectives.[133,134] A push towards model development can also be observed, for instance, in the MESSAGE-Access household fuel choice model,[87] and in the IMAGE GISMO model, which now incorporates access to basic services (nutrition, water, sanitation, and energy) and consequent impacts on human health.[135] While these approaches lend themselves towards analyzing the SDGs (i.e., the exploration of very many quantitative dimensions and trade-offs),[62] they are arguably less-suited towards uncovering the social practices and innovations that underlie more efficient forms of provisioning.

The Provisioning Context

An understanding of how biophysical resources are converted into well-being outcomes cannot be abstracted from the basic claims of well-being theory. Economic utility perspectives emphasize markets as the primary mode of provisioning. In the eudaimonic accounts, provisioning consists of the satisfaction of fundamental human attributes, both via the market and across a wider social context; accordingly, they demand that a very wide scope of circumstances are considered—social, political, and economic—within which environmental resources are mobilized and provisioned to society. These circumstances are also present in the more socio-economically oriented research into the determinants of hedonic well-being, however, they are often rendered invisible in the narrow psychological views of hedonic well-being, and also mostly ignored (or worse: assumed to be exactly known, such as economic growth) in the SDGs.

While the eudaimonic approaches suggest a very complex task in linking biophysical resources to human well-being, old and new literatures on 'provisioning systems' do provide the theoretical basis for uncovering the combinations of social systems (e.g., states, markets, or communities) and physical and technical infrastructures (e.g., supply chains, energy conversions, technologies) that lead to given outcomes.[136–139] This entails new and crucial challenges for climate change mitigation research. Namely, it requires the interdisciplinary engagement of social theory to examine and critique socio-technical provisioning systems; from the everyday practices of how humans use and interact with technologies, to the wider social relations, behaviors and norms that shape patterns of production and consumption.[140–144] Rather than simply studying social patterns of consumption, however, this research should be oriented towards the end-point of human well-being satisfaction,[114] and prepared to engage with the politics inherent in changing production patterns, given the power of vested interests.[145]

CONCLUSION

Our review can be summarized in three main points. First, human well-being can and should form a keystone of climate change mitigation research. Emission reductions entail human as well as economic costs, and it is only by considering human well-being explicitly that it can be rendered compatible with mitigation targets. However, the term 'human well-being' encompasses diverse, sometimes contradictory, theories and metrics. In order to inform changes in the social and technical provisioning systems necessary to support well-being, the most appropriate frameworks for mitigation research describe well-being as multidimensional (with no substitution between dimensions), satiable (there is such a thing as 'enough' to live a good life), and socially based (rather than depending solely on individual attitudes). Well-being theories from the eudaimonic tradition, such as capabilities and human needs frameworks, are thus better-suited to inform climate change mitigation research than hedonic or happiness approaches.

Second, well-being research provides a foundation for examining important normative issues in climate change mitigation. Proposals for a basic social minimum are generally supported by eudaimonic theories. Where these minimums entail consumption in the form of critical energy services, the distributional

implications for the global carbon budget are non-trivial. Conversely, both hedonic and eudaimonic well-being research support a threshold hypothesis for consumption: that many consuming activities can be substantially reduced or substituted through alternative forms of social provisioning without a concomitant impact on well-being. Well-being theory therefore enables researchers, communities and stakeholders to have informed and normative discussions about which activities and sectors meaningfully contribute to social progress, and where low-carbon alternatives to these can be found. The local contexts of human needs and provisioning systems demand that such discussions are procedural and iterative; they also provide a counter-narrative to the contemporary framing of well-being as consumerism.

Finally, the normative transparency that a well-being lens can bring to mitigation research has an important role in furthering political debates in the field. The recent model of science-policy interaction suggested by Edenhofer and Kowarsch argues for placing value assumptions centre stage in the deliberation process over alternative mitigation options.[146] Ongoing research streams that link up biophysical resource use to well-being outcomes could certainly contribute to this agenda. However, such an approach will also face considerable opposition, as narrow economic-based arguments often dominate the political discourse. A current trend is to reconstitute the political framing of well-being in hedonic terms, but this does little to address the fundamental distributional concerns revealed by eudaimonic research and indeed obstructs socio-economic reform.[147] A research agenda for fostering universal well-being within environmental limits cannot therefore remain naïve to vested interests embodied in fossil capital.[141] It will need to directly address a scarcely researched phenomenon in the political economy of climate change mitigation: the manifold roles of power in shaping everyday patterns of consumption, reproducing socio-economic inequalities, and directing prevailing narratives of progress and well-being.

ACKNOWLEDGMENTS

The authors are grateful to Dominic Lenzi, Lina Brand Correa, Jonathan Busch, Dan O'Neill, Andrew Brown, and two anonymous reviewers for their insightful discussions and suggestions. Julia Steinberger acknowledges the support of the UK Economic and Social Research Council (ESRC) for the Centre for Climate Change Economics and Policy (CCCEP) (Ref.: ES/K006576/1) and the UK Engineering and Physical Sciences Research Council (EPSRC) 'iBUILD: Infrastructure BUsiness models, valuation and Innovation for Local Delivery' project (Ref.: EP/K012398/1).

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