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Defining Habitability

David J. Wrathall[1], Alex de Sherbinin[2], Michael Oppenheimer[3], Radley Horton[4]

[1]College of Earth Ocean and Atmospheric Sciences, Oregon State University, Corvallis, OR, USA
[2] CIESIN, Columbia Climate School, New York, NY, USA.
[3] Department of Geosciences & School of Public and International Affairs, Princeton University, Princeton, NJ, USA
4 Lamont-Doherty Earth Observatory, Columbia Climate School, New York, NY, USA

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Introduction

From its inception the IPCC has struggled with the existential risk of climate change: its potential to render areas of the planet uninhabitable. The aim of this contribution is to move this debate forward with a formal definition of habitability, and examine its utility in future assessments. We argue that habitability is a characteristic of environments that support three fundamental dimensions of human life: 1) human safety, 2) resilient livelihoods, and 3) the capacity of people to adapt to risk. These fundamental dimensions of human life provide the footing for a population to remain in an environment intergenerationally, in pursuit of individual and collective wellbeing, self-actualization, dignity and development (Horton et al. 2021). Migration is one signal of changing habitability, and occurs when the changing natural environment alters individuals' subjective judgements about the desirability, stability or predictability of environmental conditions that support it, compared to other accessible locations. Individual determinations about habitability change through time, and are inter-subjective, meaning they interact with systems-level determinations. Thus governance is a fundamental component of habitability, although it is routinely omitted from assessments. In the end, habitability is a choice that people make collectively, and invest in. Here we build on earlier work (Horton et al. 2021) to elaborate on the dimensions of habitability.

Three dimensions of habitability

While few definitions of habitability appear in the literature, there are many examples of virtually uninhabitable spaces with extremely sparse human populations, such as hyperarid or polar regions. Such regions are characterized by extreme temperatures, drought and disaster risks that are unfavorable to human physiology and unconducive of livelihoods. Yet, even in the most extreme and hostile environments, people have developed and adapted extraordinary tools to provide safe, sustainable modes of living. Climate change, or other threats, may undermine one or more of the following dimensions of habitability: human safety and survival (Xu et al. 2020), livelihood security (Tanner et al. 2015), and societies' collective capacity to adapt to environmental risks (Barnett & Adger 2018).

Calibrating to Safety

The first dimension, *human safety,* is dependent on the basic conditions supporting the human body's basic physical health, and psychological wellbeing (Betts 2013) in the context of environmental extremes, variations and permanent changes. Environmental change can threaten local human survival and render human life physically or emotionally unsafe. Always present in the context of environmental risks and responses are the policy conditions that contribute to human safety, which include evacuation plans, shelter protocols, emergency medicine, humanitarian aid, etc. (Nicholls 2013). Broader notions of emotional safety also require us to consider a collective ability to pursue collective wellbeing, foregrounded on persistence of place-based kinship networks, cultural identity, attachment to place and community (Adams & Kay 2019).

In general, risks to human safety and survival may result in patterns of *forced* migration, in which migrants have low agency about the timing, location, or manner of mobility (Betts 2013). The IPCC AR6 concluded that the more agency migrants have (i.e. the degree of voluntariness and freedom of movement), the greater the potential benefits for sending and receiving areas (IPCC AR6 Ch.7, 2022). Conversely, forced migration, and the social and environmental conditions that produce it, generally results in negative outcomes and can be deleterious to sense of safety. A rich body of literature provides evidence that dangerous sudden-onset climate hazards (e.g. coastal flooding and storm surge) can be detrimental to safety in the short-term, leading to various forms of forced mobility (e.g. evacuation, displacement and migration) (Hauer et al 2020). These short-term extremes can also be convolved in permanent, irreversible changes (e.g. coastal erosion or inundation) that are detrimental to safety in the long-term.

Calibrating to Livelihoods

Livelihoods, the second dimension of habitability, are the required "capabilities, assets (stores, resources, claims and access) and activities required for a means of living" (Chambers & Conway 1992 p.), and *livelihood resilience* is the notion of a "capacity of … people across generations to sustain and improve their livelihood opportunities and well-being despite environmental, economic, social and political disturbances" *over time* (Tanner et al 2015 p 23). A critical component of people's ability to make a living is their *access* to the essential financial, social, natural assets that serve as inputs (Tanner et al. 2015; Cottier et al. 2022). Climate change impacts may directly impact essential livelihood assets, but crucially important, they may undermine the broader institutions, economies, and ecosystems that provision access to livelihood assets (Ribot 2010).

Globally, the largest share of migrants include people pursuing economic opportunities, access to education, better livelihoods and improving socio-economic prospects (Castles, 2003). Indeed, migration is a universal strategy that people use to manage the various risks to social, economic and political stability (de Sherbinin et al. 2008; McLeman et al. 2021). However, increasing uncertainty and volatility has had significant effects on migrant flows of people whose livelihoods

and incomes are dependent on natural resources, including agriculture, aquaculture, and fisheries (Gray and Mueller, 2012; Hossain et al. 2018). In many contexts, seasonal or temporary migration is a common practice for adapting social or environmental risks (Lein 2009, Wrathall et al. 2014, Piggott-McKeller et al. 2019). Migration has been observed in response to livelihood impacts of heat stress, drought, and land degradation (Gray and Mueller 2012; Feng et al. 2010). These effects of climate hazards on migration are more pronounced in developing countries, amongst unskilled workers (Maystadt et al. 2016). Further, perceptions of future income declines are seen as significant predictors of migration (Massey et al. 2010).

Calibrating to Capacity to Adapt

The third dimension of habitability is capacity of people to *collectively adapt to environmental risk.* Collective adaptation refers to any adjustment that people make to environmental conditions or changes that avert harm and exploit opportunities (IPCC AR6 2022). Harsh natural environments, persistently exposed to extreme heat and cold, and/or wetness and dryness, can become habitable to specific peoples and cultures over long time scales through the process of adaptation (McLeman 2011). Adaptation is generally oriented around the pursuit of locally-determined goals, such as meeting nutritional requirements or protecting investments (Eriksen et al. 2015). Considerable literature is dedicated to the cultural tools, livelihood practices, environmental engineering approaches, customs and belief systems that allow people to meet their goals from the environment (Owen 2020; Whyte 2018; Koslov 2016). The ability of people to marshal specific adaptive strategies in response to risk is a subject of rich study (see Owen 2020), and it is generally agreed that successful adaptation can occur when people are able to make use of assets, flexibility, organization, learning and agency (Cinner et al. 2018; IPCC AR6 SPM 2022). Considerable literature also examines *access* or entitlements (à la Amartya Sen) to the resources from which adaptation occurs (Ribot 2010). Of particular concern are the limits and barriers to adaptation, including "local economic and institutional dynamics that limit individuals' and groups' access to environmental, financial, and social resources necessary to respond to variability and environmental change" (Barnett & Adger 2010 p 120). Adaptation literature distinguishes between barriers to adaptation – i.e., the obstacles that can be removed or overcome, including values, institutional constraints (see also Moser & Ekstrom 2010; Adger et al. 2009), and the limits to adaptation, including immutable biophysical constraints on adaptation (see Dow et al. 2013).

Habitability may be threatened when the sources of capacity for adaptation are at risk. Household, socioeconomic, institutional, and environmental factors that undermine a particular social group's capacity to adapt to environmental threats and achieve societal goals. A range of acute and chronic stressors may undermine the organizations and institutions that confer social groups with basic needs and services. Historical evidence suggests that threats to capacity for adaptation may result in a slow depopulation and eventual abandonment of places where environmental threats impair the functionality of community services, such as schools, water provisioning systems, postal services) or render them inoperative (Gibbons et al. 2006; McLeman 2011). An array of social factors such as local governance, degree of political and economic

isolation, and social cohesion within the community can affect the community's capacity to adapt (Barnett and Adger 2007).

Habitability raises two fundamental considerations for adaptation. First, adaptation occurs across timescales as people learn from successes and failures (Rippke et al. 2020). A history and familiarity with hazards that increase by degrees of severity provides experiential analogues for future threats, and thus provide a tool kit for adaptation. Secondly, collective adaptation occurs across scales, involving input, organization and coordination at higher institutional levels (Adger et al. 2005; Ribot 2010; Thomas et al. 2019). Adaptation is therefore contingent on power differentials. Within communities, differential social vulnerability (i.e. the relative degree of social or economic exclusion, marginality and disenfranchisement) may produce adaptation needs for some people, but not others (Taylor 2013). This vision of adaptation breaks from state-centric notions of risk management and instead considers the multiple levels of collective organization necessary for people's wellbeing and dignity and development over the long-term (Adger et al. 2014). The basic insight from the adaptation literature is that modes of human life are not determined by the environment, but by the capacity of humans to organize in innumerable novel ways (Whyte 2018).

Conclusion

Future habitability will be dependent on our global decisions about greenhouse gas emissions and local decisions about adaptation. As places become uninhabitable, we can anticipate migration, and migrants who will need housing, jobs, schools, healthcare in their new communities. Because policy choices largely determine questions of human survival, livelihood resilience and whether or not to adapt, we can be assured that we have influence over habitability. Habitability is a choice.

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