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Drivers of society-nature relations in the Anthropocene and their implications for sustainability transformations

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Human impacts on the Earth system mark the dawn of a new geological epoch, the Anthropocene. This claim has triggered a debate in science, media, and politics in which 'humanity' as a whole is commonly identified as the driving force of epochal environmental change. The historically and geographically specific expansion of capitalist society-nature relations and the associated social differentiation have led to persistent social inequalities, challenging the assumption of humanity as a homogenous driver. Based on a review of social and political ecology literature, we propose a differentiated research agenda focusing on drivers of accelerating resource use in the Anthropocene. As many current governance instruments replicate and reinforce these drivers, such a research agenda can offer crucial insights for sustainability transformations.

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Introduction

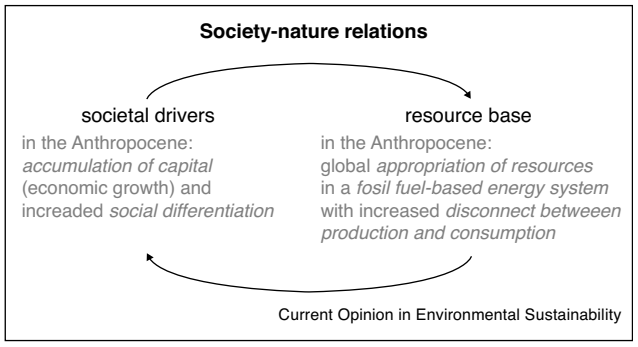
The Anthropocene literature considers changes to the Earth system caused by human activity as sufficiently fundamental to justify the definition of a new geological epoch in which 'humanity itself has become a global geophysical force' [1]. In an unparalleled manner, the Anthropocene thesis has captured scientific and popular attention, providing interdisciplinary sustainability research with a productive entry point for the in-depth study of society-nature relations. Deepening the links between Anthropocene and other types of interdisciplinary sustainability research is mutually beneficial: the Anthropocene debate has an audience which is receptive to the magnitude of challenges for sustainability research, while the debate stands to benefit from a differentiated perspective on society-nature relations. Such a perspective is necessary as much of the Anthropocene literature has identified 'humanity' or 'mankind' as the driving force of epochal ecological and geological change without further elaborating on the societal drivers. In our review, we highlight that social and political ecology, in particular, offer concepts and methods for a differentiated analysis of society-nature relations as a specific interaction between societal dynamics and biophysical resource use (Figure 1). In these two branches of research, particular emphasis is on the complex societal dynamics and power relations that drive the use of biophysical resources and the related societal impacts on the Earth system. These drivers have led to 'persistent social inequalities and vast regional differences' [2•] which challenge the assumption of humanity as a homogenous driver. A focus on drivers is crucial in advancing the understanding of the Anthropocene's trajectory, and it leads, we conclude, to far-reaching challenges for political and governance responses.

Epochal change in the Anthropocene

In 2000, Crutzen and Stoermer [3] formalized the term Anthropocene 'to emphasize the central role of mankind in geology and ecology'. Since then, researchers have proposed and debated different starting points of the Anthropocene for its formal recognition as a new geological epoch [4–6]. With the Neolithic revolution and the beginning of agricultural production, the Earth's surface was altered through deforestation, land cultivation, and the expansion of human settlements ('early Anthropocene') [7,8]. Increasing human influence on the Earth system since the late 18th century coincides with the industrial revolution, the use of fossil energy, and the associated rise in concentration of carbon dioxide and methane in the atmosphere [9,10•]. Since the 1950s, a 'growing imprint of the human enterprise on the Earth System' has been observed as the 'Great Acceleration' in production and consumption patterns and their environmental impacts [1,11•].

The Anthropocene concept is closely related to other pivotal concepts in sustainability research: It is in this new epoch that thresholds for specific biophysical processes (e.g., climate, biodiversity, nitrogen cycle), defined within the *planetary boundaries* debate, are being approached or crossed [12,13]. Furthermore, the far-reaching changes of the Earth system have motivated the study of *resilience* [14–16], building upon the understanding of fundamental

Figure 1



Society-nature relations in the Anthropocene are characterized by societal drivers and their relation to the resource base.

interdependence between *social and ecological systems* [17,18].

In this review, we focus on the drivers of Earth system changes highlighted by Anthropocene research and on the insights that social and political ecology have to offer. Better understanding these drivers is a prerequisite to the changes that a sustainability transformation requires [19]. Recent contributions to the Anthropocene debate have challenged the notion of an aggregate and undifferentiated entity of 'humanity' driving epochal environmental change. These contributions distinguish between world regions and/or social groups and their specific impacts on global environmental change [2•,11•,20••]. Next to such precise conceptualization, interdisciplinary and collaborative research [21,22], in particular a productive engagement with social science and the humanities [23], are needed to address political and governance implications of Anthropocene research. In order for this collaborative research to be successful, differences in the representation of nature, society and their interaction must be considered [24–26].

Societal drivers in the Anthropocene

In conceptualizing society-nature relations, social ecology of the Vienna school [27] defines society as simultaneously socio-cultural and biophysical. Societies reshape their environment in order to obtain material and energy inputs and to discharge waste and emissions, that is, to maintain their social metabolism [28]. Interventions into the environment aimed at reshaping natural systems according to a society's needs and wants are analytically framed as 'colonization' of nature [29]. Land is deforested, tilled, and irrigated to enable societally useful biomass harvest, soil and rock are moved so that minerals can be mined, and built infrastructure and the use of fossil fuels enable the transport of goods and people. Society not only acts upon its environment, it also reacts to this (changed) environment in a mutual, reiterative relationship [17,18]. Whereas societies have always reshaped their environment, the Anthropocene is characterized by a new quality of society-nature relations in which societal drivers have led to unprecedented changes to the Earth system (Figure 1).

The transition from an agrarian (mainly based on biomass energy) to an industrial (mainly based on fossil energy) mode of production and living was related to very rapid societal change [30] and unintended environmental side-effects (anthropogenic climate change in particular) [31]. The growing use of fossil fuels coincided with the global expansion of capitalism and unprecedented changes in economic, social, and political organization and differentiation [32,33•,34,35]. These changes acted as drivers of increasing resource use: The capitalist system requires economic growth through the continuous accumulation of capital which has relied and continues to rely on the global appropriation of labor and resources [32,36]. Resources, such as land or raw materials, are appropriated through enclosures and commodification, that is, through parceling and definition of boundaries which are associated with specific use of these resources (private property rights, e.g., companies' rights to use land for plantation agriculture, carbon traders' rights to use forests as a carbon sink) and exclude competing users and uses [37,38••].

The drivers originating in capitalist production and consumption materialize in historically and geographically-specific institutional arrangements, practices, and power relations [39••]. The Industrial Revolution and the Great Acceleration after World War II can be characterized by the specific society-nature relations of decisive periods of capitalist expansion and intensification (e.g., Fordism, Neoliberal Globalization) [40–42]. Industrialization began in the United Kingdom and other European countries and became increasingly global. Historically and geographically institutionalized drivers determine access to, control over, and use of resources. Power relations impact which social actors may make and carry out decisions with regard to resource use and impact who experiences the benefits or the burdens of resource use patterns [43–45]. For example, the explosive growth in consumption (crucial for anthropogenic environmental change) during the Great Acceleration was strongly dominated by the Global North: By 2000, 15% of the global population used roughly the same amount of energy as the remaining 85% in the Global South [43]. In 2013, almost half of global GHG emissions were caused by only 10% of the world population [46,47]. The growing middle classes in the emerging economies have begun to close the international gap in consumption [48•,49], often at the expense of rising subnational economic inequality, in which energy consumption plays a pivotal role [50,51].

Inequalities in resource consumption and the continuous growth in global resource use are decisive characteristics