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Sustainability and Environmental Sociology: Putting the Economy in its Place and Moving Toward an Integrative Socio-Ecology

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Abstract: The vague, yet undoubtedly desirable, notion of sustainability has been discussed and debated by many natural and social scientists. We argue that mainstream conceptions of sustainability, and the related concept of sustainable development, are mired in a "pre-analytic vision" that naturalizes capitalist social relations, closes off important questions regarding economic growth, and thus limits the potential for an integrative socio-ecological analysis. Theoretical and empirical research within environmental sociology provides key insights to overcome the aforementioned problems, whereby the social, historical, and environmental relationships associated with the tendencies and qualities of the dominant economic system are analyzed. We highlight how several environmental sociology perspectives—such as human ecology, the treadmill of production, and metabolic analysis—can serve as the basis for a more integrative socio-ecological conception and can help advance the field of sustainability science.

Keywords: economic development; growth; social theory; human ecology; treadmill of production; metabolic rift

1. Introduction

In environmental scholarship, the influential concept of sustainability has been discussed and debated by many natural and social scientists. Extraordinary efforts have been made to systematize sustainability and to set environmental goals over the last several decades. For example, since the 1970s, scholars have held national and international conferences to discuss the relationship between economic growth, natural limits, and environmental sustainability. At the same time, environmental problems have continued to worsen—such as the acceleration of global climate change, decrease in biodiversity, increase in water pollution, and depletion of fisheries, to name a few. Despite the ongoing effort of the sustainable development project, environmental problems have magnified [1–3].

The scientific literature on sustainability is quite vast. Part of this research employs a diversity of scientific assessments and indicators of sustainability and sustainable development, including the Ecological Footprint [4], Environmental Sustainability Index [5], Global Scenarios Group [6,7], and Genuine Progress Indicator [8]. These tools and measures are just a few of the well-known efforts aimed at increasing systematic knowledge for advancing sustainability goals and sustainability science. The distinct assessments highlight the diversity of ecological conditions and the complexity of interactions within and between social and natural systems. The prevalence of different research programs stems from myriad theoretical assumptions, scientific conceptions, and questions regarding

the social implications of sustainability [9,10]. Additionally, the discourse around sustainability and sustainable development has generated debates and contrasting meanings and conceptions [11,12].

We argue that many mainstream conceptions of sustainability—and the related concept of sustainable development—are mired in a "pre-analytic vision" that naturalizes capitalist social relations, closes off important questions regarding economic growth, and hinders socio-ecological analysis. A pre-analytic vision provides the initial conceptual categories and base assumptions for analyzing a particular phenomenon [13]. We offer a critique of the extant pre-analytic vision found in many approaches to sustainability in order to present a critical inquiry of sustainability and sustainable development. We draw on critical social theorists, particularly Karl Polanyi and Karl Marx, to reveal how this pre-analytic vision, which readily privileges economic growth, developed. In doing so, we illustrate the importance of putting the economy in its place—namely, within the larger social and ecological systems. We address how theoretical and empirical research within critical perspectives of U.S. environmental sociology provides key insights to help overcome the aforementioned problems, whereby the social, historical, and environmental relationships associated with the dominant economic system are analyzed. Finally, we highlight how several environmental sociology perspectives—such as human ecology, the treadmill of production, and metabolic analysis—can serve as the basis for a more integrative socio-ecological conception of sustainability and contribute to the emerging field of sustainability science.

2. Development and Sustainability

Modern theories of sustainability and sustainable development appear in the post-Second World War era [1,14]. This particular period in world history influenced the institutional framework, meaning, and application of these concepts, especially in relation to increasing concern regarding the vast inequality between nations [11,12,15,16]. Specifically, the United Nations and other global institutions, such as the World Bank, helped construct what was meant by sustainable development in major debates and discussions regarding economic development. Within universities, scholars of development studies and development economics incorporated the concepts into their evaluation of the global political-economic system. Both modernization theory and development theory became the leading social science approaches for understanding and addressing the problems of the "Third World" [1]. These theoretical perspectives were rooted predominantly in neoclassical economic theory, which had several implications for the policies they informed and for the definitions of development and underdevelopment [14].

Some major tenets of neoclassical theory are that economic growth (or the expansion of market-based economic activity with a resulting increase in gross domestic product) will have beneficial effects on all sectors of society, that markets are self-regulating (*i.e.*, market equilibrium will produce optimal utility), and that rational actors make cost-benefit decisions that will maximize utility. Development theorists operating in a neoclassical economics paradigm argued that what was essentially needed for social progress in the formerly colonized societies was an unleashing of capital in the parts of the world where capital had not yet fully made its mark. This would increase the potential for expansion and economic efficiencies. They maintained that policies encouraging such actions would have the desired effects of propelling these areas into new, grander "stages" of economic growth that would result in progress toward "mature" societies [17].

The United Nations and the Bretton Woods institutions (the World Bank and the International Monetary Fund) have been central institutions promoting industrial capitalist development. These organizations provided much of the original planning and financing for development projects throughout the world, and such funding continues to this day [1]. Environmental problems gained more social attention in the latter part of the twentieth century, many of which could be directly tied to the global expansion of industrial capitalism. Some institutions, such as the United Nations, began to consider that environmental issues might need to be addressed within development models and

funding plans. As a result, the mainstreaming of the concept of sustainable development is borne largely out of U.N. projects [18].

In 1972, the United Nations Conference on the Human Environment was held in Stockholm, Sweden. This was the initial conference in a series organized by the United Nations on development and the environment that took place over the next 40 years. These conferences were commissioned to examine the escalating environmental impacts occurring throughout the world and to work toward developing new global legal frameworks that could better address the growing environmental and social concerns associated with capitalist development. The initial Stockholm conference resulted in the creation of the United Nations Environment Program (UNEP) whose mission is "to provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations" [19]. This statement contained a preview of the popular conceptions of sustainable development.

Over the next 40 years, the United Nations hosted a series of conferences, including the well-known meeting in Rio de Janeiro, Brazil, in 1992 (*i.e.*, Rio Summit or Earth Summit), where "sustainable development" was the central theme. In 1992, the Commission on Sustainable Development was established out of proposals in Agenda 21 [20,21]. The best-known definition of sustainable development was a product of the U.N. World Commission on Environment and Development (WCED), which was formed in 1983 and is also known as the Brundtland Commission. The Report of the WCED, "Our Common Future", was published in 1987, creating a pleasingly formulaic definition of sustainable development as "development that meets the need of the present without compromising the ability of future generations to meet their own needs" [22].

Thus, for more than four decades the United Nations has been promoting a vision of development that has included a conception of sustainability. This process can be regarded as the greening of development theory, where the goals of economic development began to take ecological concerns into account [23]. While the new development model attempted to address physical realities associated with environmental degradation, the focus on economic growth did not change significantly, if at all. A common critique of the U.N. approach to sustainability is that it merely tacks on the term "sustainable" to the traditional economic development model in order to advance an era of neo-liberalism [15,18]. While the Brundlandt Report [22] does begin to address fundamental ecological and social concerns, and can be commended for some of its inclusive language and creative vision, it has been argued that the sustainability programs and initiatives created under the auspices of the United Nations have been nothing more than hollow efforts and platitudes for addressing ecological concerns [11,23,24]. Critics of the sustainable development approach have suggested that it fails to integrate ecological realties and the interdependence of humans with the rest of nature [25].

As discussed, the development project emerged from a set of historical circumstances that resulted in a definition of the concept that is largely a plan to expand the scope and scale of global capitalism. At the United Nations, resolutions and humanitarian goals, which are at the core of their mission, were often placed in a context of expanding industrialization, and ultimately global economic growth and modernization. Consequently, many view U.N. summits as key mechanisms through which transnational corporations have become principal contributors to the strategy, goals, and practices set forth for achieving sustainable development [11,24].

3. Neoclassical Economics, Sustainable Development, and the Pre-Analytic Vision

Following the 1950s, the "Great Acceleration" in the human disruption of Earth systems led to much more research regarding the types and range of environmental degradation [26]. In the 1960s and 1970s, the environmental movement gained traction, demanding fundamental changes in society. Books such as *Silent Spring* [27], *The Closing Circle* [28], *Limits to Growth* [29], and *Blueprint for Survival* [30] presented analyses that depicted how social processes, including economic growth, resulted in environmental problems. In an effort to diminish extreme forms of degradation, many wealthy nations passed environmental regulations and laws due to increasing social pressure.

As discussed, by the 1980s, the private sector, particularly large corporations, became more involved in environmental policy conversations, in large part to protect their economic interests. At the 1984 meetings of the Organization for Economic Co-operation and Development (OECD), the position that the economy and environment are "mutually reinforcing" was established as a focal point for sustainable development [31]. This proposed compromise between economic development and environmental protection served as the basis of the Brundtland Report. Along with the previously mentioned definition, this report stated that "The concept of sustainable development does imply limits—not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities. However, technology and social organization can be both managed and improved to make way for a new era of economic growth" [22]. Effectively, this definition couples economic growth and sustainability. Further, in some prominent interpretations, economic development is even assumed to provide the basis for sustainability. These positions reveal the taken-for-granted epistemic presuppositions that are found in the mainstream neoclassical economics tradition, which influence many conceptions of sustainability and sustainable development.

For example, environmental economist David Pearce indicates that "most economists" define sustainability entirely in terms of economic growth, monetary wealth, and consumption, without any direct reference to the environment. From this perspective, sustainable development is really sustainable economic development, which necessitates "continuously rising, or at least non-declining, consumption per capita, or GNP" [32]. Indeed, economic development becomes the central feature of sustainable development, and nature becomes a secondary consideration, at best. Consequently, economic models predicated on the growth imperative are central to modern economics and dominate policy discourse. Ecological economist Herman Daly points out that the ecological fact that the earth is essentially a closed and limited system, in which there are absolute limits as determined by natural science, runs contrary to the dominant economic paradigm [33].

Mainstream economics and policy operating largely within the neoclassical economic paradigm generally conceive of nature as a subsystem of the economy. In this view, the macro-economy becomes the primary point of analysis, which subordinates ecosystems. Everything, including biophysical nature, falls within the dynamic of the macro-economy [33]. This perspective has had a long history in economic thought, going back to the classical economists who regarded nature as providing "free gifts", and up until the present period where some modern economists argue that everything in nature can be substituted with the help of technology. For example, Robert Solow, a Nobel laureate in economics, argued that "if it is very easy to substitute other factors for natural resources, then there is in principle no 'problem'. The world can, in effect, get along without natural resources, so exhaustion is just an event, not a catastrophe" [34]. Such notions of endless substitutability and rejection of ecological limits are characterized as "weak sustainability", at best.

The Brundtland Report, environmental organizations, and mainstream sustainability approaches embody these orienting assumptions, whereby sustainable development is, underneath it all, about maintaining endless economic growth and technological solutions. It is important to note that the discipline of economics has many subfields, which develop varying approaches to scholarship. While mainstream neoclassical economics has been challenged for its lack of ecological awareness, other heterodox approaches, such as ecological economics, have developed theories and methods that are consistent with our critique. In fact, we draw directly from heterodox economists, including Herman Daly and others, who argue that neoclassical economics omits essential conceptual categories for understanding the relationship between economic and ecological systems.

Daly—following Joseph Schumpeter—argues that a growth-oriented approach serves as an important part of a "pre-analytic vision" that guides academic and policy groups, omitting essential relationships and categories from evaluation [13,33,35,36]. This pre-analytic vision is at the core of neoclassical economic models, but also provides the underpinnings for a common conceptual framework of sustainability or sustainable development throughout contemporary environmental

discourse, scholarship, analytical examinations, and policies. This vision has frequently been formulated into heuristic devices, and is often used to conceptualize sustainability using metaphors like the "three legged stool", "three pillars of sustainability", and a "sustainable development triangle" [37–40]. Each of these conceptions proposes a similar vision, revolving around environmental, economic, and social factors that converge on sustainability. These are regarded as practicable and reasonable approaches for evaluating and achieving this important socio-ecological goal.

The business community has adopted this perspective, labeling it the "triple bottom line", consisting of people, planet, and profits [41,42]. The triple bottom line view has received significant attention as a sensible approach toward sustainability [43]. Government agencies, international organizations, businesses, and universities alike employ these heuristic devices and depictions to plan and communicate their sustainable philosophies and practices [37]. For example, the OECD states: "All of the economic, social and environmental systems must be simultaneously sustainable in and of themselves. Satisfying any one of these three sustainability systems without also satisfying the others is deemed insufficient" [44]. In other words, environmental policies are deemed acceptable so long as they create opportunities for economic growth.

The triple bottom line/three pillars description of sustainability emphasizes the importance of environmental, economic, and social concerns, and all three are considered central to the broader definition of sustainability [42]. In fact, it is argued that these three pillars serve as the foundation upon which sustainable development must be built, providing the outline for achieving what Andres Edwards calls a "sustainability revolution" [38]. Numerous researchers have employed variants of these models that sometimes include other factors (e.g., climate, fresh water, fisheries) depending on the focus and scope of the particular questions and problems [45,46].

While these three pillars are obviously important, there are critical flaws in the pre-analytic vision garnered from neoclassical economics. One central problem is that what constitutes the economy—within the three pillars conception—is limited to a growth-oriented market system. As we will elaborate in the next section, neoclassical economic assumptions are based on a pre-analytical vision in which the economic order of capitalist growth is naturalized. Therefore, its central relationship as a driver of environmental degradation falls outside of the analysis. Economist John Kenneth Galbraith proposed that this "innocent fraud" avoids the importance of conceiving of capitalism as a historical system, preventing an adequate analysis and understanding of the forces shaping the world [47].

4. Why It Is Necessary to Put the Economy in Its Place

Ecological economists and environmental sociologists argue that a weak sustainability position as outlined above is completely insufficient for addressing the ecological challenges we confront. Instead, a strong sustainability perspective must serve as a starting point. We suggest that this can add depth to the meaningful contributions coming from the scholarly work in the field of sustainability science. A sociological conception of history, economic relations, and ecology provides a more systematic understanding of these matters. From this perspective, the existence of ecological limits and planetary boundaries are cornerstones to analyses of sustainability. The capacity to substitute—by technological means—for environmental resources, as suggested under the weak sustainability approach, is inadequate. Maintaining the conditions that support life is of utmost importance. As ecological economist Richard Norgaard suggests, the organization and operation of the economic system must be critically examined, in order to offer a more comprehensive understanding of how interactions between human society and the larger physical world influence each other [48]. These concerns establish a broader conception of sustainability, and present important questions such as: do we prioritize sustaining the economy or sustaining the environment? In much of the sustainable development literature, it is commonly assumed that there should be a focus on both sustaining the environment and the economy. We argue this seemingly sensible and balanced approach has

been largely a pretext for furthering business as usual, since the economy is conceived of as always consistent with capitalist preconditions.

It is important to establish a foundation that allows alternative viable conceptions of sustainability and society to emerge, challenging the pre-analytic vision that informs many conventional economically oriented approaches, particularly those in the tradition of neoclassical economics, on which we elaborate below. A first step in creating a more integrated socio-ecological analysis, which can inform discussions of the complex interactions and relationships of sustainability, involves recognizing that economic systems are embedded within the biosphere. This position stands in contrast to standard models such as the triple bottom line and its variants, which regard economic concerns as an independent realm (*i.e.*, one leg of the stool), existing in their own right, as if they are separate from the larger biophysical world. Furthermore, it is just as important to analyze the dominant economic system as a socio-historical system, rather than naturalizing its social relations. In doing this, the distinct and general characteristics of the economic order can be examined, especially as far as they act as social drivers of environmental degradation. This analysis allows for the potential for social transformation to be recognized as a positive force. Here, we offer a brief critique of the naturalization of the modern economic system that is an essential part of the pre-analytic vision discussed above. We highlight the ecological and social contradictions that arose with the ascent of capitalism, and the necessity to re-embed the economic system within the socio-ecological order.

The naturalization of capitalist social relations is not a new analytical presupposition. Both Karl Marx and Karl Polanyi indicated that this was fundamental to the work of some of the most famous founders of political-economic thought, particularly William Thompson, Adam Smith, Jeremy Bentham, David Ricardo, and Thomas Malthus [49,50]. Elaborating on this issue in *The Great Transformation*, Polanyi asserted: "the drive for a competitive market system acquired the irresistible impetus of a process of Nature. For the self-regulating market was now believed to follow from the inexorable laws of Nature, and the unshackling of the market to be an ineluctable necessity" [50]. Consequently, in a vigorous political battle to renounce and ultimately eliminate the English Poor Laws, leading economic thinkers with clear class interests were ideologically compelled to assume that the capitalist economy is guided by laws comparable to those of governing nature [49–51].

Economist E.K. Hunt explains that this move to naturalize capital and the system was crucial to the new science of economics that took shape in the late nineteenth century, under the theoretical guidance of those who ushered in what is commonly referred to as "the marginalist revolution" [52]. In this neoclassical theory, economics was modeled after the natural sciences, specifically physics, which attempted to develop a dispassionate, value-free study that could interpret the so-called laws of the market [53]. In this view, the modern global economy, based in commodity production and exchange value, is universalized and theorized as a natural system, akin to biophysical systems. Accordingly, "a new abstract universal, namely 'the economy'" was objectified, which reified modern social relations as relations between things [54].

Paradoxically, while neoclassical economic theory tended to naturalize the existing economic order, the material basis of economic development was torn from its ecological foundations. As Marx explained, part of this is due to the inherent characteristics of capital as an economic system based on generalized commodity production. Economist Paul Sweezy elaborates, "it is this obsession with capital accumulation that distinguishes capitalism from the simple system for satisfying human needs [as] it is portrayed in mainstream [neoclassical] economic theory. And a system driven by capital accumulation is one that never stands still, one that is forever changing, adopting new and discarding old methods of production and distribution, opening up new territories, subjecting to its purposes societies too weak to protect themselves. Caught up in this process of restless innovation and expansion, the system rides roughshod over even its own beneficiaries if they get in its way or fall by the roadside. As far as the natural environment is concerned, capitalism perceives it not as something to be cherished and enjoyed but as a means to the paramount ends of profit-making and still more capital accumulation" [55].

As Sweezy clearly describes, capitalism is a dynamic system, with a general character rooted in endless accumulation. As a grow-or-die system, capitalist development must expand exchange value, which is purely seen as a quantitative measure [56,57]. Qualitative relations, such as the conditions of life, are not a primary part of capitalist accounting. This foundational tendency towards expansion or "development" pushes the economic system onward, increasing the scale and breadth of its impacts upon the biophysical world [49,58,59]. Thus, ecological limits are easily explained away within this neoclassical conception.

Polanyi provides further insight into this matter when describing the social transformations that arose due to capitalist social relations. Prior to this development, Polanyi argues, economic systems of production and consumption were clearly embedded within the institutions and cultural practices of societies. Labor and distributional activities were influenced by principles of behavior including householding, reciprocity, and redistribution, rather than limitless economic gain [50]. In other words, people, customs, and social institutions set limits and regulated economic productive activities, directing them to serve particular ends, such as human needs. Max Weber advanced a similar argument in his most famous work *The Protestant Ethic and the Spirit of Capitalism*. That is, he argued that a variety of social conditions, particularly religious institutions, limited the expansion of capitalism around the world until the specific influence of the Protestant religions (namely particular beliefs and actions of Calvinists) of Western Europe provided the impetus for its full development [60]. What is common in these analyses is the recognition that human economies and its organizations are embedded within society and, we emphasize, the larger ecological complex that support life.

Polanyi, similar to Marx, explains that under a capitalist market economy, all aspects of social life become subordinated to the requirements of the economic realm. He maintains that "all transactions are turned into money transactions"—in order to meet the needs of capital [49,50]. The emergence of an all-encompassing self-regulating market "disembedded"—in terms of coming to dominate and alienate social relations—practical human activity from its foundation in the broader sociocultural and natural conditions. As a result, market activity directed by commodity production "acquired the irresistible impetus of a process of nature". Accordingly, the organization of social production and consumption activities is fundamentally transformed from an emphasis on the exchange of qualities into the exchange of quantities. Alienation from each other and from nature increases, as qualitative relations are subsumed under the quantitative growth imperative of capital and a culture of quantity [61]. Polanyi explains that during the transformation toward capitalist social relations "it was necessary to liquidate organic society". This "divorcedness of a separate economic motive", which is unique to capitalism, and therefore relatively new in human history, became commonplace [50].

Drawing from these social theorists it is clear that conceptualizing the economic sphere in a way that detaches it from society and/or nature results in a flawed understanding of social relations and ecology. Consequently, the economic system can be easily formulated as an autonomous self-governing force, and meeting economic needs can become separated or "divorced" from social and ecological concerns. The divorcing of ecology from the economy is consistent with neoclassical economic theory and political ideology that prioritizes specific economic (class) interests and universalizes capitalist social relations, turning comprehension of issues such as sustainability inside out. That is, the economic system is prioritized. Transferred into the modern sustainability models and policies, putting the economy on an ahistorical platform that independently erects a pillar of sustainability becomes a plausible step.

From a sociological perspective, it is clear that economic institutions and relations arise through socio-historical processes. They cannot be analyzed outside their socio-historical environment any less than they can be extracted from the natural environment. Clearly, it would be inappropriate to exclude other social institutions from our conception of society, such as, for example, religious life and its related institutions. The various institutions that make up our modern economy are no less social than past economic arrangements, or other non-economic social institutions [60]. The emphasis granted to modern economic institutions in environmental policies, for example prominence given

to "the market", is a reflection of ideological priorities and commitments, not material conditions. Thus, we must understand how social institutions interact with each other and with ecosystems when considering how to develop an integrated socio-ecological analysis that informs sustainability.

The economy obviously plays a major role in modern social life, but it should not be extracted from its place within the social sphere. Doing so mis-prioritizes historically specific and unique economic arrangements, giving them undo primacy and inevitability. It also results in approaches toward sustainability in which economic indicators, such as gross domestic product, become fundamental guides for addressing ecological and human welfare. This is the case with the sustainable development project, which essentially uses the template of the traditional development project whereby economic growth and free trade are the foremost goals, reflecting the priorities of global capitalism [1,18].

The larger contextual setting in a socio-ecological approach is the greater Earth system. When social and economic systems are properly conceptualized as existing within the Earth system, we can analyze economic systems as part of socio-historical processes, situated within relationships of power, that are dependent on ecological systems [16,26]. Economies by necessity involve social relations. Economic action is social action. Economies are comprised of social institutions and networks, and societies manage economies. As Polanyi made clear, the "economy, as a rule, is submerged in social relationships" and "the economic system is, in effect, a mere function of social organization" [50]. Thus, what the purpose of an economy is and how it should be organized are important questions to consider for a sustainable society.

While capitalist social relations have distinct properties, they arose through socio-historical conditions and processes. In this, they are not inevitable, and can be changed. There are alternative economic arrangements and systems that have existed and can be created. At the same time, it is necessary to understand the operations of the capital system, its inner characteristics, especially if and how the endless drive to accumulate generates environmental degradation and social inequalities. Sweezy declares that it is important "to ask whether there is anything about capitalism as it has developed over recent centuries to cause us to believe that the system could curb its destructive drive and at the same time transform its creative drive into a benign environmental force". He argues, "unfortunately, there is absolutely nothing in the historic record to encourage such a belief" [55]. The array of environmental problems we confront is in part a consequence of this economic system and its inherent drive to constantly increase the accumulation of capital. Its business-as-usual operations are contributing to escalating concentrations of greenhouse gases, the loss of freshwater, and decreasing biodiversity [62–66]. Any discussion of sustainability must account for the role that the modern economic system plays in influencing the human dimensions of environmental change. This requires calling into question the pre-analytic vision that supports maintaining the capitalist market as a cornerstone, or further, a precondition of sustainability.

If we continue to rely on conceptions of sustainability that exclude critical questions related to the role of the modern economy, models that are ecologically and socially problematic will continue to be produced. Importantly, it will become increasingly difficult to develop proper indicators to measure the improvements and/or deficiencies of sustainability projects. Excluding important data, such as the historically specific growth dynamics of the economy, ignores the elephant in the room and generates scientifically imprecise models that ignore the inner logic of capital and its operations. Tyndall Centre climate scientists Kevin Anderson and Alice Bows indicate that this is exactly what is happening in regard to discussions concerning climate change. There is an enormous "discontinuity" between climate science findings and mainstream neoclassical economic emphases on exponential growth and unregulated markets [62]. Rather than taking the implications of climate data seriously, assurances about future technical fixes and the feasibility of adaptation and resilience are offered as solutions. The importance of dramatic social change is sidestepped. Furthermore, contesting charges of being political, biased, and alarmist for contravening prevailing economic beliefs and interests of corporate and public policy elites, Anderson and Bows contend, climate scientists "repeatedly and severely underplay implications of their analyses" [62]. As a result, it is all the more important to recognize

that if the theoretical assumptions of neoclassical economics are fatally flawed, ensuing policies cannot work toward achieving the essential goals.

Approaches to sustainability and sustainable development influenced by neoclassical economic models and its underlying pre-analytic vision have produced little, if any, progress toward addressing global ecological challenges. Indeed, upon examining the scientific research, it becomes clear that there has been decline of ecological and social systems since these matters were taken up during the last half-century or so [2,4,26]. Important work by natural scientists suggests that business as usual cannot solve the myriad ecological problems facing the world today. Addressing sustainability requires putting the economy back in its place, as a subsystem within the larger social and biophysical systems [13,67,68]. This re-conceptualization and re-embedding will benefit from employing an integrated socio-ecological approach, informed by insights from both the natural and social sciences. Specific perspectives, which, for example, have developed within U.S. environmental sociology, can help advance such work and add new dimensions to the analyses being provided by sustainability science scholars.

5. Towards an Integrated Socio-Ecological Approach

Environmental sociology provides necessary insights for developing a rich understanding of sustainability. We elaborate on specific approaches that emerged in the United States. The sub-discipline arose as a field of study in the 1970s, proposing that the biophysical world must also be a realm of social inquiry. Early scholars argued that the presuppositions of contemporary sociology, similar to the pre-analytical vision within neoclassical economic thought, were "human exemptionalist", and implied that society existed outside and/or largely independent from relationships with the biophysical world [69,70]. Since then, environmental sociology has become a leading field of study, analyzing the interrelationships between human systems and natural systems. Several distinct research traditions have been created that provide useful analytical tools for considering issues related to socio-ecological sustainability, which overcome several of the problems discussed earlier.

From an environmental sociological perspective, traditional sustainability approaches like the triple bottom line/three pillars or the United Nation's sustainable development agendas are inadequate. For environmental sociologists, human systems are embedded within the larger Earth system. Additionally, economic systems are seen as socio-historical products that arose through specific social relationships within the larger biophysical world. Thus, the capitalist economic order is not naturalized, avoiding the pre-analytical vision that plagues so much of sustainability studies and sustainable development policies. As a result, environmental sociologists advance a research program that begins to assess the importance of various social institutions that are crucial for understanding sustainability. Many of the perspectives within environmental sociology are focused on examining the dynamic relationships in socio-ecological systems. We will briefly discuss three prominent theoretical approaches—human ecology, treadmill of production, and social metabolic analysis—and emphasize the contributions that environmental sociology can make to sustainability science.

The human ecology tradition provides useful conceptions and tools that offer a basis for an integrated socio-ecological approach to sustainability, avoiding tendencies within social and economic analyses toward human exemptionalism. Counter to the prevailing approaches in sociology of the period, theorists and researchers within human ecology argue that society is embedded within the larger ecological complex, comprised of reciprocal relationships between population, organizations, environment, and technology [71–74]. Culture mediates human relationships with the natural environment, but does not exempt humans from ecological and biophysical limits [69,75–78]. They analyze how growth dynamics—especially population and economic—influence the Earth system, altering material conditions and the availability of resources. These scholars incorporate feedback loops into their studies, emphasizing that the larger biophysical environment also constrains and influences social conditions. Human ecologists argue that all organisms and societies require energy expenditure to be sustained and that social organization shapes material resource flows and energy

consumption levels. The scale and intensity of energy consumption, in relation to natural cycles, such as the carbon cycle, and the availability of carbon sinks, influence whether or not these social actions are sustainable. Further, variable population characteristics (e.g., size, growth, age structure, and migration), combined with other factors in the ecological complex (e.g., economic inequality), generate distinct patterns of ecological impact.

Human ecologists offer multifaceted assessments of interactions within the ecological complex and account for historical change. They contend that preindustrial societies generally relied on limited supplies of biomass for energy, which restricted population growth and development of complex social organizations [79–81]. By employing steam engines and greatly increasing coal consumption and energy output, human ecologists argue, industrial societies enormously increased productive capacity, sociocultural complexity, and population growth, stimulating demand for more energy [80]. These scholars propose that modernity's exceptional rates of population and economic growth have generated unparalleled resource demands and waste and that it is a primary social driver of environmental degradation and the accumulation of carbon dioxide in the atmosphere, contributing to ecological overshoot [75,82]. Thus, the overall demands are expanding beyond ecological limits, and that, when controlling for population size, developed nations consume the bulk of resources and produce most of the pollution and carbon dioxide [82–87].

Treadmill of production scholars also situate the economic system within the larger Earth system. They primarily provide a political-economic analysis of the historical development of modern industrial society, particularly the demands that the capitalist economic order places on the environment, and the consequences of its operations. Avoiding the pitfalls of the pre-analytic vision of neoclassical economics and human exemptionalism discussed above, they do not proceed from capitalist social relations as a givens. Instead, the dominant economic system is created through historically distinct human and institutional interests and must constantly recreate itself. Given the inner dynamics of the economy, profits must constantly increase, which are reinvested to enlarge and intensify the scale of production. On this treadmill, accumulation takes precedence and drives a cycle of growth that necessitates ever-increasing production [88]. Treadmill theorists highlight how this growth imperative heavily influences the organization of production, and drives culture-nature relations. They argue that private capital, the state, and labor depend on economic growth for profits, taxes, and wages, creating a type of path dependency with an array of social and ecological consequences.

The constant pursuit of profit and expansion has "direct implications for natural resource extraction", pollution generation, and overall environmental conditions [89]. Treadmill theorists explain that each expansion in the production process to sustain economic operations on a larger, more intensive scale generates higher natural resource demand, often at rates that exceed ecosystem regenerative capacity and that contribute to an increased disorganization in nature [67,88–92]. Moreover, they contend that energy-intensive materials, such as plastics and chemicals, which are incorporated into manufacturing, generate widespread waste and pollution that producers externalize [91–94]. As a result, ceaseless economic growth generates environmental degradation. The treadmill of production approach suggests that the modern capitalist economic order is generally incompatible with sustainability.

Similar to treadmill of production scholars, theorists and researchers in the social metabolic tradition analyze capitalism as a historically specific regime of accumulation that drives the growth imperative. They view this social order as a distinct social metabolic system that operates in accord with a particular logic, reducing labor and nature to means of further capital accumulation. This system fundamentally shapes material exchanges with the environment. Relentless growth increases demands on ecosystems and the larger environment. Like human ecologists, social metabolic scholars incorporate the operation of natural cycles and systems into their analysis in order to better assess the interpenetration and exchanges between society and its biophysical bases. They indicate that capitalism's social metabolism exceeds natural limits, producing "metabolic rifts" in various cycles and processes, which are necessary for ecosystem maintenance and regeneration [57,58,95–97]. Metabolic

theorists specify that capitalist social relations tend to generate ecological rifts in specific ecological cycles through the intensification of the social metabolism. For example, the capitalist growth imperative locks in dependence on burning massive quantities of coal, natural gas, and oil [98,99]. This process has resulted in breaking the solar-income budget, releasing enormous quantities of carbon that had been sequestered. At the same time, consequent growth-driven, ecological degradation (e.g., deforestation) substantially reduces carbon sinks, further contributing to the accumulation of atmospheric carbon dioxide, resulting in a carbon rift that drives climate change. Similarly, social metabolic studies have also been applied to help elaborate on the ways in which modern capitalist development has fundamentally altered marine systems [100–103] Capital accumulation processes have been demonstrated to play a primary role in the structure and function of, for example, the seafood industry, which has guided fishing activities on a global scale. This analysis has illuminated how economic forces lead to fish being harvested at a rate faster than they can reproduce, thus contributing to the "fishing down the food web" process of capturing species of a lower trophic level and potentially to the collapse of fisheries [104].

These three theoretical traditions in environmental sociology challenge the tendency within mainstream sustainability studies to treat environmental issues as largely technical problems. The techno-optimist position of many sustainable development models helps maintain the pre-analytic vision, ignoring the role of the economy in producing environmental problems. Promoting technological solutions as the answer, such as simply improving the energy efficiency of production, maintains the status quo and limits the potential for social change. A more sophisticated understanding of technology and socio-ecological relationships is necessary to advance a more comprehensive conception of sustainability.

Treadmill and metabolic theorists propose that technological innovation plays a crucial role in capitalist development, rationalizing labor processes and generating cost reductions via automated production. They hold that new technologies often make energy and raw material usage more efficient, but, contra neoclassical environmental economists, contend that innovation does not necessarily dematerialize society or contribute to an absolute decoupling of development from energy and resources. They suggest that more efficient resource usage can often increase aggregate consumption of that particular resource—creating a socioeconomic dynamic known as the Jevons paradox, named after the nineteenth-century economist William Stanley Jevons [105–108]. In *The Coal Question*, Jevons noted this paradoxical relationship, whereby increased consumption outstrips gains made in energy efficiency [106]. He, however, did not provide a full explanation for why this occurred. Metabolic theorists, drawing upon insights from Marxist political economy, explain that efficient operations produce savings that expand investment in production and thereby promote increased production and consumption, and accordingly total energy consumed, raw materials used, and carbon dioxide produced [67,109,110]. To understand why this paradox arises, it is necessary to consider how the growth imperative of capital and processes of accumulation influence these dynamics. These critical environmental sociological perspectives reveal that technological rationalization must be situated within the global economy's overall social relations and operations. It is inappropriate to assume that technological innovations, such as improvements in energy efficiency, automatically lead to less environmental impacts. The most efficient nations are often found to be the largest consumers of natural resources [111].

Human ecology, the treadmill of production, and social metabolic analysis offer more nuanced understandings of the interactions between social, economic, and ecological realms. They raise critical questions regarding how the economy is traditionally conceived within sustainability studies. They indicate that it is important to embed the economy within society and the larger Earth system. These perspectives also suggest that an economy should be organized to meet social needs in an ecologically sound way, rather than for the sake of endless growth and accumulation. The social metabolic approach offers important insights in regard to how the independent and relational dynamics of socioeconomic

and ecological systems can be examined in a fruitful way to inform sustainability research and create an integrated socio-ecological analysis.

We contend that environmental sociology has great potential to address the social and ecological challenges associated with sustainability. A very important aspect of social metabolic analysis is the role it can play in better linking the natural and social sciences on sustainability. Sustainability science is an area that has gained increasing notability, which can benefit from further contributions from environmental sociology.

Some within the natural sciences have recognized the necessity of developing an environmental science that integrates "societal and political processes that were shaping the sustainable development agenda" [112]. Several established approaches aiming to accomplish these goals can be placed under the umbrella of sustainability science. As a growing area of interdisciplinary environmental research, sustainability science "seeks to understand the fundamental character of interactions between nature and society" [112]. Here we briefly mention two prominent approaches: Coupled human-natural systems (CHANS) and resiliency. These overlapping multidimensional approaches have done much to advance sustainability science.

CHANS and resiliency scholars analyze interconnected complex systems [113]. Based in a systems theory model of scientific analysis, these approaches recognize that reducing ecological systems to isolated parts, common in modern environmental management schemes, is fundamentally flawed. Unlike neoclassical economics, that models linear changes in simple cause-and-effect relationships, these approaches highlight the complexity of interacting systems, that systems can be subsumed in other systems, and multi-scalular effects. CHANS scholars emphasize that changes can occur at different levels of a system and can cascade up or down [114]. Further, these systems-based approaches stress that coupled human and natural systems or "social-ecological systems" are highly dynamic and heterogeneous [115,116].

Resilient systems are understood as systems that can maintain their structure and capacity for long-term renewal, even in the face of various impacts, shocks, or disturbances [115–119]. Resilient socio-ecological systems tend to be more robust with regard to diversity and health. In contrast, when socio-ecological systems are overstressed due to resource exploitation or overwhelming waste inputs, these systems are weakened, less likely to maintain regenerative capacity, and less resistant to perturbations. As thresholds are breached, "ecological discontinuity" can occur with few, if any, immediate warning signs, drastically changing the system conditions [119–121]. Such changes affect both social and ecological outcomes in complex and often surprising ways, which can have serious implications for associated human communities. Underlying CHANS and resiliency research is the conceptualization of human systems as embedded in ecological systems, and that social and ecological systems are in constant interaction. An emphasis is placed the unity of what the resiliency literature calls "social-ecological" systems, highlighting the integrated nature of conditions.

These two approaches are very important, yet they do not adequately address the general and specific characteristics of the socio-economic system, especially its inner driving force. Thus, sustainability science must better integrate critical political-economic insights, which environmental sociology can offer, such as the dynamics associated with the growth imperative of capital, the social and ecological contradictions that arise from commodity production systems, technological innovation and the Jevons paradox, power and inequality, and the institutional conditions that produce social tendencies toward particular ecological outcomes [96,103]. We contend that further incorporation of environmental sociological approaches, such as human ecology, treadmill of production, and social metabolism, will advance sustainability science toward an improved analysis of coupled human and natural systems. It is essential that the social dimensions of integrated systems are not simply folded into functionalist ecological models [122]. The growth of sustainability science approaches, such as CHANS and resiliency research, have produced important steps in moving away from the traditional sustainability paradigm and flawed pre-analytic visions, and would benefit from a deeper integration of environmental sociological approaches.

6. Conclusions

Conventional views of sustainable development and sustainability are rooted in problematic presuppositions that lack important political-economic insights. That is, historically specific social relations and institutions cannot be transposed into trans-historic, natural systems that exist alongside nature, or even conceived of as largely separate from the biophysical world. A central theme in both Marx's and Polanyi's work is that it is absolutely necessary to describe the social nature of the modern capitalist economic system. They also stressed the political and ecological dangers of mis-conceptualizing the economy as a natural system.

Sustainable development paradigms based on the ill-conceived triple bottom line/three pillars models are fundamentally flawed in that they do not recognize the socio-historical nature of economic conditions and that all social conditions exist in a material reality, namely within the larger Earth system. They suffer from a pre-analytic vision, drawn from neoclassical economics, which assumes that the economic pillar is independent and simply means the ongoing pursuit of endless growth. Here the role of capitalist social relations in the creation of environmental degradation is sidestepped. Critical questions are ignored and technological solutions are repeatedly proposed, neglecting a serious discussion of social transformations. Fortunately, several theoretical traditions within environmental sociology provide insights for better articulating the socio-ecological circumstances, and the roots of the socio-ecological concerns of modernity.

We suggest that the emergence and development of sustainability science has come a long way toward addressing the gaping holes in the more traditional sustainable development approaches. In particular, sustainability science that emphasizes that human and natural systems are coupled are promising, given the emphasis that these systems must be studied together, in interaction. While making headway, sustainability science has not sufficiently drawn upon the power of critical approaches within environmental sociology in developing analyses, and thus has not appropriately engaged social dynamics and has sometimes been susceptible to functionalism. Human ecology, treadmill of production, and social metabolism can greatly enhance the studies of sustainability, and particularly contribute to insights into matters of political-economic power, environmental degradation, inequality, and social justice.

Sustainable socio-ecological systems must not only be resilient, but also socially just. Environmental sociological theories can clarify the connections and interactions between institutional dynamics and their ecological outcomes. They call into question mechanical, functionalist analyses that are rooted in a pre-analytic vision that naturalizes the economic system. Societies that are more equitable have greater potential for socio-ecological sustainability and resiliency [117]. Under these conditions, individuals and communities participate in a social form and manner that prioritizes sustainability and equity, the purpose of which is to facilitate social/human development and to enhance human welfare and dignity. Thus, the larger community must be invested in and benefit from these processes of change. Under such a system, accumulation for accumulation's sake is not the focus. Instead, the economy is deeply embedded within a society and must recognize natural limits, which can allow for a radical qualitative and quantitative shift in humanity's relationship to the Earth system [90]. The goals are to better address environmental change, lessen the human demands placed on ecosystems, and promote socio-ecological sustainability.

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