Toward a Deeper Understanding of Sustainability within HCI

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ABSTRACT
HCI researchers have contributed numerous articles in the area of sustainability; however, much of this work is skewed towards environmental sustainability. Future HCI research must take a more comprehensive view of the environmental, social, and economic facets that make up sustainability. This paper defines sustainability and each of the three facets, reviews existing HCI research that overlaps with these facets, and suggests directions for HCI to help achieve sustainability in the future. The paper concludes with a set of remaining questions to consider for future HCI research in sustainability.

Author Keywords
Sustainability; environmental sustainability; economic sustainability; social sustainability; post-sustainability

ACM Classification Keywords
H.5.m. Information interfaces and presentation: Misc.

INTRODUCTION
Drexhage and Murphy's 2010 United Nations International Institute for Sustainable Development Report [11] provides context for how sustainable development has evolved since the 1987 Brundtland Report [3]. In it, they note that climate change is the de facto "home" for sustainable development, and while good progress has been made on sustainable development metrics (e.g., alleviation in Asian poverty, energy access in all developing regions, phase out of ozone-depleting substances), the implementation of sustainable development has been ineffective [11]. Specifically, the challenges lie within the integration of the three facets of economic, social and environmental sustainability [11]. The authors note the lack of progress in fulfilling platforms (e.g., policies and programs) to better the lives of the poor [26] and note the need for systemic change to how we think about and act upon sustainable development.

These unsustainable trends include unprecedented material and resource consumption that negatively impact the environment [3]. Large portions of the natural world have been converted to human use, prompting concerns about the ability of the world's natural resource base to sustain such growth.

Incomes and wealth also reveal a large and growing gap between the rich and the poor, which presents an increasing tension between economic and environmental sustainability. In fact, income inequality has been rising in most countries over the past two decades [21, pp. 138-143], especially so in middle-and high-income countries, where the incomes of richer households have increased relative to those of the middle class and poorer households [20]. Frieden finds that the decline of global inequality is primarily resulting from successful development in China and India [14]. The world overall, however, remains extremely unequal—while the world's poorest 50 percent represent just one percent of the world's wealth, the richest one percent of the world's population possesses 40 percent [6].

The trend in categorizing sustainability as a climate change, or energy issue is also prevalent among HCI researchers.

I support HCI expansion beyond topics of environmental sustainability such as eco-feedback and energy consumption, and into topics within the economic and social pillars of sustainability. In this paper, I identify as an "established" researcher in HCI sustainability and discuss the following questions:

- What is sustainability?
- What do we know about how sustainability might be achieved?
- How can HCI help achieve sustainability?
- What crucial questions remain?

SUSTAINABILITY
What is sustainability? From an ecological perspective, sustainability is "conserving an ecological balance by

avoiding depletion of natural resources" (http:// http://www.oxforddictionaries.com). However, at the 1987 Brundtland Commission of the United Nations, the term sustainable development was defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [3] Today, sustainability most commonly refers to Brundtland's definition of sustainable development, though there have been some issues with the lack of clarity of this definition. For example, in 2011, Baumer and Silberman noted that this definition avoids the controversial issue of what counts as a "need," and raises ethical, political and even design issues [1]. Though the definition itself lacks clarity, sustainability brings together aspects of economics, sociology, resource management, public policy, and ecology [19]. In fact, since the definition was originally written, three essential pillars of sustainability have been identified as [e.g., 19; 29]: economic, environmental, and social.

According to Drexage and Murphy, good progress has been made on sustainable development metrics, but implementation has been ineffective [11]. Implementation challenges lie within the integration of the three pillars of sustainability [11], and there has been a lack of progress in fulfilling platforms such as policies and programs to better the lives of the poor [26]. Another challenge is the need for systemic change to how we think about and act on sustainable development.

Similar arguments have been made within the context of the HCI community [12, 1], and I advocate the continuing promotion of HCI work within both social and economic sustainability. I also support the argument that the term, "sustainability," carries so many nuances and implications that it must be defined whenever it is used in order to be properly understood [24].

Therefore, I start by defining each of the three aspects of sustainability. In addition to providing examples of HCI work that offer meaningful impact, I propose opportunities for further HCI development.

Environmental

Robert Goodland, the former environmental adviser to the World Bank Group, defines environmental sustainability as the "maintenance of natural capital" [17, p.10], where natural capital is the Earth's reserve of resources that provide goods to sustain life (e.g., water, absorption of carbon dioxide, fossil fuels, biodiversity).

According to Goodland, this definition constitutes input/output rules, which are detailed in the paper. Essentially, we must maintain two fundamental environmental services over the period that sustainability is required—the "source and sink" functions [4]. The source constraints include the use of renewable and nonrenewable resources, and the sink constraints include pollution and waste assimilation.

HCI researchers have contributed numerous articles in the area of environmental sustainability. In fact, sustainability within the context of HCI is heavily skewed toward issues of climate change in the environment, and specifically toward one source constraint—the consumption of non-renewable resources such as, fossil fuels, natural gas, oil and coal. A few exceptions include works such as [28; 23], which bring up discussions of renewable energy [28], and electronic waste disposal [23].

Nevertheless, environmental sustainability prevails. For example, of the 139 sustainable HCI papers, Froehlich et al. found that 56 were related to eco-feedback technology [15]. Eco-feedback technologies provide feedback on individual or group behaviors with the intention of reducing environmental impact [15]. In a critical analysis of persuasive sustainability research from 2009-2011, Brynjarsdóttir et al. found that persuasive sustainable works are heavily focused on individual consumption and behaviors [4]. Though the focus on individual consumption is somewhat limiting, some HCI research focuses on issues of social sustainability as well (e.g. citizen science [14], social capital [7]). We define and discuss these sustainability aspects in the next section.

Within the context of HCI and environmental sustainability, we must learn how to measure the impact of our existing research. Perhaps there is a need to connect with experts in fields outside of HCI (e.g., environmental engineering, ecology, economics, public policy), to help us understand how to measure our past impact and to help us measure our environmental impact going forward. In addition, these experts could help prioritize the actions in our field that will have the most positive environmental impact. For example, should HCI researchers further explore non-renewables and sink constraints such as pollution and wastage?

Social Sustainability

Stephen McKenzie from the Hawke Research Institute at the University of South Australia defines social sustainability as "a positive condition within communities, and a process within communities that can achieve that condition" [24, p.23]. A few examples of indicators, or features of the "condition" include: equity between generations (e.g., future generations will not be disadvantaged as a result of the current generation's activities); equity of access to services such as education and transportation, housing, recreation, and health; means for "political advocacy to meet needs that cannot be met by community action" [24, p.23]; and a sense of community ownership. Topics of social justice, community resilience, and social capital are all topics of social sustainability.

Social sustainability may be perhaps the least popular sustainability pillar. Nevertheless, a small but growing body of HCI research, particularly around citizen science, community resilience [9], politics [12], and the importance of social capital [7, 8] addresses issues of social sustainability explicitly.

Despite directly identifying as sustainability, or particularly social sustainability researchers, several HCI researchers address the same topics, but do not classify their research as sustainability. These HCI research topics include topics of social justice [13], citizen engagement [27], equity of services such as health [2, 18], and a wide range of information and communication technologies for developing countries (ICT4D). Perhaps understanding the overlap of social sustainability and existing HCI research could help to illuminate where HCI fits into social sustainability research, and help to evaluate our impact. .

Economic Sustainability

The "maintenance of capital," or keeping capital intact is the widely accepted definition of economic sustainability [17]. Economic sustainability relates to the maintenance of levels of government and external debt [19]; the maintenance of current jobs and the creation of new ones; the promotion of price or quantity changes that alter economic growth; and the accounting of natural resources, incentives, or the creation of incentives that encourage sustainable practices [19].

Today, the scarcity of natural capital is an economic concern, and the difficulties lie in translating monetary units of value to the valuation of intangible, intergenerational, and common access to resources such as air [17]. Another issue is that the dominant paradigm within economic sustainability is development as economic growth [17]. Though the implied goal of economic development within sustainability is to narrow the equity gap between the rich and the poor, achieving this goal has been quite unsuccessful and unpopular among some politicians [17].

As with social sustainability, few HCI researchers identify as economic sustainability researchers. A recent HCI article addresses the issue of economic sustainability among individuals from economically distressed areas of Detroit, MI, and the topics overlap issues of economic and social sustainability. The paper suggests solutions such as the sharing economy, which promote the creation of new jobs and creating incentives to encourage sustainable practices. Technological platforms and applications that promote the sharing economy (e.g., AirBnB, TaskRabbit), and job creation (e.g., oDesk, MTurk), and trading (e.g., Craigslist) are relatively understudied within HCI. One exception is Irani and Silberman's technology, which promotes ethics and sustainability among Mechanical Turkers [22]. Nevertheless, exploring areas in which the three pillars of sustainability overlap is also an interesting direction for the future of HCI sustainability research.

ACHIEVING SUSTAINABIILTY

Sustainability will ultimately be achieved [17] (whether we like it or not). In other words, we may be able to alleviate the "timing and nature of that transition and the levels of sustainability to be sought, or we can let depletion and pollution dictate the abruptness of the final inevitable transition" [17, p.14].

Understanding how sustainability might be achieved less severely, particularly within HCI, is a difficult question.

In a keynote speech at the 28th annual Rev. Dr. Martin Luther King Jr. Symposium at the University of Michigan, Harry Belafonte[1] conveyed the message that artists have the ability to shine a light on society's problems (e.g., through song, artwork). Though HCI researchers and technologists have the ability to shine a light on society's problems, we also provide platforms that enable individuals and groups to act on today's problems (e.g., change.org, twitter hash tag trends). However, technology is not perceived as an empowerment enabler [7]. Understanding how technological platforms are used as mechanisms to achieve sustainability (e.g., citizen science, [24]) and ways to promote technology as a mechanism to achieve sustainability should be further explored.

However, first evaluating the definition and components of sustainability may lead us in the right direction. Toward that end, we must: 1) perform a holistic evaluation and assessment of our work within the three facets of sustainability; 2) identify if and how our work in HCI can have greater impact within the three facets of sustainability; and 3) determine our future priorities and focus.

CRUCIAL QUESTIONS

In defining the three facets of sustainability, crucial questions remain. Understanding whether we are in alignment with other fields such as ecology, economics, sociology, political science, and public policy in terms of sustainability is key. How might we best align with other fields in a way that benefits everyone? Specifically, how do we measure sustainability in HCI? From a social sustainability perspective, how do we measure community resilience [9]? What sustainability measurements within HCI are needed?

Lastly, and perhaps a question out of scope with this workshop: Where do we stand in determining whether environmental sustainability allows for economic growth?

CONCLUSION

In this paper, I have defined sustainability and each of its three pillars: environmental, social, and economics. I have also identified key HCI research contributing to these areas. I highlighted the prevalence of environmental sustainability work in HCI and the disengagement between HCI researchers that do and do not identify as sustainability researchers, yet conduct sustainability research. Finally, I raised crucial questions to consider regarding the conflict between environmental and economic sustainability.

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