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Corresponding Author	Family Name	**Nardi**
	Particle	
	Given Name	**Bonnie**
	Suffix	
	Organization	University of California, Irvine
	Address	Irvine, USA
Abstract	Human computation includes the accumulation of social wisdom in the form of progressive social agendas. These agendas developed rapidly during the twentieth and twenty-first centuries through the distributed intelligence made possible by advanced information technologies. Progressive social agendas build toward equality among groups differentiated by race, class, gender, sexual orientation, and similar factors. It is no accident that these trends, distinctive in human history, occurred during an era in which national and international communication and the creation and widespread dispersal of information were enabled by advanced technologies. In this chapter I discuss future threats to social progress and the importance of maintaining the information and communication technologies and infrastructures that underpin such progress.	

The Role of Human Computation in Sustainability, or, Social Progress Is Made of Fossil Fuels

Bonnie Nardi

The Probable Future

We in the Global North enjoy historically high levels of wealth and economic security. Our present abundance seems inevitable, deserved, stable. We do not believe our lives will ever be like those of people who lived during the Great Depression, or of struggling middle and lower classes in chronically economically depressed areas of the world. Yet a sober look at economic and environmental indicators strongly suggests that we are headed for a future of decreasing abundance. The goal of this chapter is to sketch a future of economic decline and discuss how we should prioritize computational resources to prevent the erosion of social gains achieved during the twentieth and twenty-first centuries. The argument is not about "saving the environment" or sustaining current lifestyles (which is impossible), but about sustaining and extending progressive social changes accrued during the period of industrial expansion. Human computation emerges as a positive force when collective human intelligence and technology are used together to solve problems and promote progressive changes (see Hourcade and Nathan, this volume). In this chapter, I make an argument for the likelihood of economic decline, and contend that information technology will serve an indispensable role in maintaining social progress. Technology has the capacity to help us defy historical patterns in which decline leads to regressive social trends in human relations.

Progressive change is built on what Clay Shirky calls a "cognitive surplus" (Shirky 2010). Shirky describes the cognitive surplus as abundant wealth that allows time for online participation such as crowdsourcing, writing fan fiction, game modding, and so on. But the notion of cognitive surplus is more general: wealth affords

With apologies to Tomlinson and Silberman (2012), of which more in a moment.

B. Nardi (✉)
University of California, Irvine, Irvine, USA
e-mail: nardi@ics.uci.edu

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people the time and energy to do things other than meet basic needs. We have a lot of free time because our economic system is so productive. In this chapter I draw attention to one of the things some people have done with the cognitive surplus: develop and promote progressive social agendas. Some people spend their surplus watching television (up to several hours a day), but luckily for most of us, a persistent, energetic collection of various kinds of activists has been spending theirs looking out for our rights.

For most of human history, rights for workers, women, children, LGBTQ[1] persons, the disabled, the aged, the ill, and minority populations were unheard of. The dominant group (usually able-bodied men of the primary race/ethnicity) simply ran things. As an anthropologist I had the opportunity during the early days of my career to live in two such societies, one in Western Samoa and the other in Papua New Guinea. These were village-based societies with low levels of literacy, practicing agriculture with hand tools. Although communities in these cultures provided close social bonds of the sort that have eroded to some degree in industrial society, and the communities produced beautiful art, it was also true that women had no voice in governance, the disabled were ignored or ridiculed, and people with alternate sexual orientations were devalued. "Domestic violence" was not even a linguistic category of action because hitting women and children was seen as a natural mode of discipline. Old people, unproductive in a horticultural setting, were often isolated and untended as they grew feeble and sick.

Largely during the twentieth and twenty-first centuries, conditions changed as social activists addressed themselves to an Enlightenment agenda of progress, defined as equality for less equal groups. In industrial societies, workers and minorities were important groups for whom it was necessary to extend rights, in addition to women, the disabled, and so on.

We have not by any means solved the problems of inequality. Groups such as the mentally ill, homeless, and those addicted to drugs, are still often completely outside societal protections. We are a ways from true equality for all groups. Nonetheless, it is important that we recognize the immense progress that has been achieved. This progress is recent, tenuous, expensive to sustain, and far from stable. Looking to the future, equality is threatened in a scenario of economic decline because the cognitive surplus will be reduced as wealth is reduced. If we are economically stressed we will address ourselves to what will reasonably seem like more pressing problems such as food security, maintaining social order, providing shelter.

Is there a role for information technology in sustaining hard won gains in social equality? I believe there is. This chapter sketches probable causes for economic decline, followed by a discussion of what we know of "collapsed" societies historically, and how information technology might enable us to defy historical patterns. Both activist and technical activity will be necessary. Human computation should include using human cognitive capacity to understand how to deploy technical resources wisely, with compassion and social foresight—not only for instrumental

[1] Lesbian, gay, bisexual, transgender, queer.

purposes of efficiency and corporate profit. I argue that notions of human computation must, recursively, develop a clear sense of why we are using computation in the first place, understanding how it enhances human life. Vint Cerf recently called upon the ACM membership to "develop better tools and [a] much deeper understanding of the systems we invent" (2012). Cerf acknowledges that in its short history, computer science has transformed human experience, but he also notes that it has offered much less in terms of tools and practices for comprehending what it has unleashed. The call for the *Handbook of Human Computation* identifies "creativity, intuition, symbolic and logical reasoning" as central to human computation. These capacities derive from our lengthy sociobiological evolution from primitive humans to *homo sapiens sapiens*, but the speed with which we have only recently developed sophisticated information technologies along with a progressive social agenda, derive directly from the cognitive surplus.

The Wealth of Our Nations

Tomlinson and Silberman (2012) argue that "the cognitive surplus is made of fossil fuels." They remark that while Shirky takes the cognitive surplus as a given and seeks only to describe it, we must also understand how the cognitive surplus is possible, and why it occurred during the current historical era. Tomlinson and Silberman observe that our free time is not really quite so free:

> Both the free time that forms the "raw material" of the cognitive surplus and the technologies and practices of coordination that enable it to be treated as a single resource rely on huge technological infrastructures. These infrastructures are largely powered by fossil fuels.

So what will happen when we run out of fossil fuels? These fuels, in particular oil, are the most energy dense substances humanity has ever had at its disposal. One barrel of oil is the equivalent of about 25,000 h of human manual labor (McKibben 2010). Hawken et al. (1999) observe that:

> Machines powered by water, wood, charcoal, coal, oil, and eventually electricity accelerated or accomplished some or all of the work formerly performed by laborers. Human productive capabilities began to grow exponentially. What took two hundred workers in 1770 could be done by a single spinner in the British textile industry by 1812.

And of course we have come a long way in efficiency since 1812.

But it is imperative to remember that fossil fuels are finite resources. Even disregarding the costs of environmental cleanup and health impacts the extraction and use of fossil fuels entail (see e.g., O'Rourke and Connolly 2003; U.S. National Research Council 2010; Epstein et al. 2011; IPCC 2012), the fact is that these resources are not forever. They will first become expensive, then prohibitively expensive, and then they will run out (see Hirsch et al.'s report for the US Department of Energy (2005)). Energy conservation, something we do not like to think much about, will be necessary.

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Alternative sources of energy such as solar will be more fully utilized in the future. But alternative energies are no match for fossil fuels in terms of energy produced. Solar, for example, does not work well when the sun is not shining. In China, where solar energy is used much more widely than in the US, residents take short showers in the winter and put up with more discomfort than Americans and Europeans are used to (Gui, 2013, personal communication). All alternative energy sources rely on at least some fossil fuels for production and distribution (Zehner 2012). There is no energy cornucopia waiting for us to tap into; we live on a specific planet, with specific resources. We are in the process of using up those resources. O'Rourke and Connolly (2003) observe that going forward it will cost more to extract remaining fossil fuels, including escalating environmental and health costs:

> On– and off–shore exploration, drilling, and extraction activities are inherently invasive and affect ecosystems, human health, and local cultures. [Impacts] include deforestation, ecosystem destruction, chemical contamination of air and water, long–term harm to animal populations (particularly migratory birds and marine mammals), human health and safety risks for neighboring communities and…workers.

It seems likely that our reliance on fossil fuels will end in an economic decline to which we will have to adapt. This reality appears all but inevitable given several factors in addition to the finiteness of fossil fuels. First, we are doing little to alter current patterns of consumption; there is no real effort to conserve remaining resources. On the contrary, we are engaging in destructive, costly practices such as fracking to extract difficult-to-access oil and natural gas. Second, it is not feasible to expect that biofuels and other sources of alternative energy will be direct replacements for fossil fuels because their equivalencies to human labor are far below that of oil (Zehner 2012). Third, there are huge social costs to alternative energies; e.g., biofuels take land out of food production (Zehner 2012).

While it might seem that humans will once again pull the rabbit out of the hat in maintaining current levels of energy consumption through advances in technology, there are two things to consider. First, the price of the current prosperity of the Global North comes at the expense of the Global South. Our global society is one of massive inequality. Considerable global collapse already exists, once we look beyond the privileged countries of the West. Meadows et al. (1982) commented, "The view that global crises will occur in the future reflects a parochial, developed-world perspective. For two-thirds of the world's population, crises of scarce resources, inadequate housing, deplorable conditions of health, and starvation are already at hand." Our "success" as a populous species is deeply inequitable, and we can therefore expect increasing civil unrest with fewer resources with which to address it because armies, drones, and so forth, rely on fossil fuels. We can expect citizens in rapidly developing countries such as China to ramp up toward Western levels of consumption which will hasten the depletion of fossil fuels. Second, technological proposals like space-based solar farms are far in the future, if they are feasible at all. They would require great quantities of fossil fuels and would cost vast sums. Given that only 12 people have ever set foot on our nearest neighbor the moon (a long time ago), and that NASA's Mars Mission's most ambitious proposal for the near future is "the return of Martian soil and rock samples for studies in laboratories here on Earth" (NASA), it is an act of denial to suggest that we sit back and

wait for technological fixes. It thus seems prudent to use some of our current cognitive surplus to ask how we can begin to design information technologies for a future of scarcity, and to engage in an exercise of prioritizing which computational resources we should guarantee in a situation of scarcity.

In this chapter I am particularly concerned with protecting social gains as the environmental dangers are well rehearsed. What could it mean to design for social sustainability? The most important point is that we must absolutely protect the global communication channels the internet has created. *Social gains in the* twentieth *and twenty-first centuries were made not at local or regional levels, but at national and international levels*. Historian Christine Stansell describes the global feminist movement and how it not only mobilized women but coalitions of diverse constituencies in various locales. For example, the abortion reform movement represents the efforts of "physicians, psychiatrists, and family planning professionals along with activists" (Stansell 2011). Although abortion reform predates personal digital technology, these gains were made with modern communication technologies, and the continuing battle to protect rights, which in the United States are always under siege, is waged in part with digital tools. Rapid progress on issues such as marriage equality and other LGBTQ concerns owes much to digital technology, as do other critical social struggles (Driver 2007; Gray 2009).

It might seem a no-brainer to advocate for a free internet. But how many of us really consider that even now the internet is vulnerable to bids for repressive government control in countries like China, and corporate control in countries like the US where issues such as net neutrality are far from settled? If, for example, corporations who own the infrastructure were to discount costs of connectivity to selected rich corporations that can afford to pay in volume, while charging the rest of us a premium, activists and ordinary citizens would suffer. As technologists we may feel that these decisions are outside our purview, *but they are in fact decisions made by technologists in corporations*. In this era of deregulation, government oversight is attenuated. The checks and balances of governance designed into the American Constitution (and similar documents in other countries) cannot operate if corporations assume governance. Lessig argues that "code is law" (2006), i.e., that the ubiquitous software systems underpinning commerce and communication dictate what we can and cannot do. Facebook can preserve everything it knows about you and use the information in ways it finds profitable. Amazon can offer cloud computing for vital services at low cost today but who knows what the pricing will be tomorrow? By contrast, bear in mind that telephony pricing was once strictly controlled by the government in order to offer universal service, and privacy protections for certain kinds of information such as health-related data were put in place before the era of deregulation. We must thus acknowledge that we are moving toward law outside democratic process. Corporations are tasked with ensuring profits, not promoting progressive social agendas (see Suarez-Villa 2012). It seems likely that a future of scarcity will make it even more tempting to increase profits by, for example, moving away from net neutrality. Thus human computation must consider how to protect and sustain a free internet. Proposals such as wireless texting and data transfer undergirded by locally controlled infrastructure should be explored and promoted (Michelucci, personal communication).

Learning from, Not Repeating, the Past

The urgency of sustaining free global communication in a future of scarcity is evident in the history contained in the archaeological record. Archaeological theories of collapse demonstrate that collapsed societies (such as the Maya, the Romans, and so on) lose complexity, *devolving to smaller scale units in smaller geographies* (Tainter 1990). When collapse occurs, the costs of governing wider areas become untenable, and social units shrink to smaller forms. It is precisely such smaller scale units (like the Samoans and Papua New Guineans I lived amongst) that assert rule by elites.

Smaldino and Richerson (this volume) note, "Larger and more connected societies can maintain more complex technologies." They comment on the fragility of connected societies: "Much of our specialized knowledge is collected by institutions, and that knowledge could rapidly vanish. Skilled people can die, books can be burned, and computers can wear out." It is only through protecting the strengths of modern information and communication technologies that connectedness, including broad coalitions of activists and citizens, can persist, uniting people to effect change and distribute control beyond small elites. In large-scale regimes of repression (such as the Soviets or the Nazis), elites maintained control by suppressing the free exchange of information and exerting stringent control over communication. Commentators such as Morozov (2013) observe that large corporations, which in the contemporary context have as much or more power as governments, are not subject to anything like the Freedom of Information Act. Are we moving toward systems in which we cannot question those who set policy? (There is some irony in the fact that Facebook, Google, etc. which traffic in information are themselves behind information firewalls.) In this historical moment of deregulation, as we cede control to corporations that furnish indispensable infrastructures without which the economy—indeed society itself—cannot operate, we must ask to what extent corporate policies protect social gains and promote continuing activism. And we must ask how we as citizens will influence those policies which operate in a universe largely outside democracy. Stansell (2011) says that feminism is "democracy's younger sister—an invocation of the linkages between progressive social forms and their necessary mutual reinforcement—as well as a reminder that protecting one involves protecting the other.

The history of social reform tells us that we do not want to return to the past, that nostalgia for simpler times is patently misplaced. It is in the current era of national and international communication and collaboration that we have rapidly won rights for the groups I discussed. Going forward, we need to use resources of human computation to prioritize sociotechnical projects to protect these rights. As Cerf said, it is important to develop a better understanding of the systems we invent, including their impacts on society. This prioritization is necessary as we envision a future of scarcity because the cognitive surplus will decline as we run out of fossil fuel. Time will be more precious. Levy (2007) invokes Thomas Aquinas to argue that time for reflection is a moral imperative, and that "self-destructive work-fanaticism" defeats efforts to live better. Without deliberately setting aside time for the most important

social projects, it will be easy to fall into "work-fanaticism" that erodes the gains we have accumulated in the era of cognitive surplus.

Since our problems—including ongoing and predicted environmental damage—are global, it is essential that we sustain and promote empowered citizens of all kinds to work together to confront what will be very severe changes. Not only are rights for women, the disabled, and so on, critical for human dignity, they are crucial for empowering all people to address the massive, pervasive changes science tells us are imminent (see Greene; Hourcade and Nathan; Meier, this volume). Information technology has the capacity to empower formerly relatively powerless groups. For example, Wicks and Little (this volume) discuss ways in which people with serious illnesses make unique contributions to healthcare through participation in online forums. The authors note that people suffering stigmatizing diseases such as AIDS deployed communication technologies to organize and change the course of AIDS research. Information technologies have had a profound impact on society in extending new kinds of participation to formerly disempowered groups. A goal going forward is to recognize the fragility of sociotechnical systems that Smaldino and Richerson (this volume) point to, and the enormous potential of the collective intelligence embodied in human computation.

We will move to a new future that does not look like the past but also is quite different from the present. We will not have the economic abundance to sustain the way we live now. What will we give up? The amount of cheap consumerist junk that overflows our landfills will decrease. It is likely that we will travel less, eat more local foods, live closer to workplaces, perhaps even grow some of our own food. Proposals for edible offices (EO 2013), revivals of the ancient art of aquaponics (Rakocy et al. 2006), and urban chicken ranching may seem a little wild-eyed, but they are on the horizon (and present interesting computational problems). These changes constitute probable improvements to current ways of life. But I hope we do not give up our global network of information and communication technologies. Research areas such as crisis informatics (Starbird and Palen 2011; Al-Ani et al. 2012), collapse informatics (Tomlinson et al. 2012, 2013), and ICTD (information and communication technologies for development) (Sambasivan et al. 2010; Toyama 2010; Woelfer et al. 2011) are beginning to address how we will sustain connectivity in less than perfect conditions by studying and designing for current situations in which resources are stressed. We have much to learn from these efforts including designing digital technologies for unstable electrical grids, ensuring communication during emergencies, and orienting ourselves to plan ahead to mitigate and even forestall problems.

Coda

As I was working on this chapter, the power on most of my campus was knocked out for several hours (something that had not happened in the 10 years I have been at the University of California, Irvine). I wrote in the glow of my battery-powered laptop,

mindful of the limited resource I on which I was now relying. As it happened, during the outage, Terry Winograd, an eminent scholar of human-computer interaction, was scheduled to give a talk to my department. We sat in a dim meeting room listening to Professor Winograd discuss his amazing life's work in which human computation has figured prominently. Professor Winograd had no slides because of the failed power, but his talk was an inspirational historical accounting of progress in human-computer interaction. Perhaps prophetically, *the internet was still working*—the university had decided that backup power would be allocated to connectivity during outages. As Professor Winograd spoke, we could tweet the event and some of the audience looked up things Professor Winograd was discussing, such as the old Eliza program with which some younger students were unfamiliar. It was a little warm and dark during the lecture, but we were enlightened! This occurrence was like a tiny visit to the future in which we will be making decisions such as: will it be slides and air conditioning or connectivity? The university had decided in advance on connectivity—surely the right choice given that had the emergency been more dire, communicating with the world and finding information would be the priorities. If we are to defy historical patterns of collapse in which social units devolve to more local forms affording less protection of progressive social agendas, we will be using the powers of digital technologies of information and communication to do so. Unlike the Maya and the Romans who did not have foresight attained through research in archaeology and history to guide them, we can assess likely future problems now, and plan for them. We understand that sustaining social gains rests on information and communication transmission at national and international scale, and we can prioritize resources in a future of scarcity just as my university prioritized internet connectivity.

The objective of this chapter has been to argue that social progress is made of fossil fuels. Once we realize the basis upon which this progress rests—and that it is not a given and it is not forever—we can plan to self-consciously expend resources to extend and maintain progressive social agendas. Net neutrality is one pertinent technological issue but there are many others including promoting broad-based computer science education to ensure that control of digital technology is not confined to technical elites, deciding who gets access to rare earth metals, encouraging citizen participation in the control of computing infrastructure, and continuing to develop innovative means of crowdsourcing to leverage whatever cognitive surplus we will have in the future. In short, at least some cycles of human computation should be used to plan for a future of scarcity in which economic decline will force us to use a smaller cognitive surplus wisely. This is just the sort of wicked problem that stands as a challenge to human computation which we can take on now, in an abundant present.

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