What If Sustainability Doesn't Work Out?

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In a recent NSF-funded National Academies symposium on Science, Innovation, and Partnerships for Sustainability Solutions, there was a great deal of discussion about global change. To offer a few concrete examples of the kind of problems that may result from global change: Sea-level rise could displace tens or even hundreds of millions of people by the end of this century [1]; similar numbers of people could be subjected to increased water stress [2]; and shifting climatic zones could cause many farms to cease to be viable with current crop choices and farming techniques. As we write this, the U.S. is experiencing the worst drought and warmest 12-month average temperatures since record keeping began in 1895 [3,4]. Figure 1 details the key predictions regarding global change made by the 2007 Intergovernmental Panel on Climage Change [5].

In his keynote at the National Academies symposium, John Holdren, head of the U.S. Office of Science and Technology Policy and chief science advisor to the nation, described a need for both mitigation—the reduction of the magnitude of change—and adaptation—the mobilization of responses to change [6]. Holdren offered that many more projects are currently focusing on mitigation than adaptation. Researchers around the world and across widely disparate fields are exploring ways to mitigate environmental problems. Mitigation is a key focus for many industrialized nations seeking to enable their citizenry to maintain or improve their lifestyles. Nevertheless, despite the significant efforts to mitigate global change being exerted across many elements of human civilizations, it is not clear that these efforts are sufficient to place humanity on a path that avoids the grave consequences of this change.

If, as increasingly seems likely, humanity is unable to prevent dra-

Photograph by Eli Blevis

matic global change, then adaptation to these transformations will be of growing relevance. The manner in which humans adapt to the changes will define the future of civilization. Here, we engage with the topic of how IT tools can support adaptation to global change.

Adaptation Informatics

Given the high likelihood of some degree of impending global environmental change—and the possibility of dramatic levels of change—we propose the need for more research in IT to explore the topic of adaptation. This research, which could be called *adaptation informatics*, entails the study, design, and development of sociotechnical systems for use in a future characterized by global change.

The goal of adaptation informatics is to use the tools of information technology to maintain a high quality of life for humans and other species, even in the face of significant global change.

Adaptation informatics builds on several existing programs of research. In one paper, a co-author of this article and his collaborator present a list of projects that form the beginning of a program in HCI and interaction design targeted at adaptation to the effects of climate change [7]. Examples include data systems that support policy decisions in the face of environmental refugee-ism; interactive systems that enable people to share knowledge of how to live with less; and an effort to develop an understanding of how trends like cloud computing, streaming, and social computing affect energy and other resource use.

Also relevant is recent work in collapse informatics under way by several co-authors of this article. A paper at CHI 2012 contains an introduction and survey of related work in that area, as well as a number of potential collapse informatics projects [8].

Other computing researchers have also begun to explore similar topics (e.g., [9]). In addition, many other fields, such as social ecology, geosciences, and ecological economics, are exploring the characteristics of futures that may call for significant adaptation.

However, the substantial emphasis on mitigation rather than adaptation in computing suggests a (perhaps naïve) willingness to believe that humanity will find a way to solve environmental problems without requiring dramatic changes to the daily practices of large numbers of people. Adaptation informatics is an excellent research topic for at least two reasons: It is vitally important and distinctly underexplored.

Adaptation Scenarios

Scenarios of adaptation to global change typically entail a less economically and materially abundant future. As climate and other factors shift, the misalignment between natural resources and human infrastructures will likely curtail the productivity of human systems. Because continuance of the resource-intensive practices characteristic of prosperous industrialized nations will no longer be possible, we must reimagine a quality of life based on less lavish, more innovative deployment of materials. Adaptation informatics will be informed by inspecting the ideologies, rhetoric, and practices of people who occupy certain cultural margins that reject the assumption that we can sustain the profligacies of contemporary society.

Tony Fry discusses a contrast between sustainable development (constraints on development as usual) and the development of sustainment (designing more sustainable lifestyles) [10]. Fry offers two design principles to support the development of sustainment: acts of redirective practice—for example, finding ways to keep computers updated while still turning them off when not in use [11]; and acts of elimination—for example, choosing appropriate local products to avoid the environmental costs of transporting goods (see [12] for compelling examples of how products are sourced globally). While simplicity and local sourcing are not guaranteed to produce the most sustainable alternative, decreasing availability of fossil fuels would likely lead to situations in which global supply chains and vast civilizational complexity are less viable options.

Important ideas for future adaptation are already being realized in existing communities and enterprises. For example, in the U.S. and Europe, "shrinking cities," such as Youngstown, Ohio, and Leipzig, Germany, are reinventing city planning to consolidate services and transform vacant land into parks and gardens. "Transition towns" are not legal jurisdictions in the way that shrinking cities are; rather, they are local, town-based groups that educate citizens about DIY repair skills, gardening, energy conservation, political actions (such as promoting air quality in neighborhoods), and other relevant matters. We want to understand how such communities and enterprises operate, how they imagine the future, and how they conceive of quality of life.

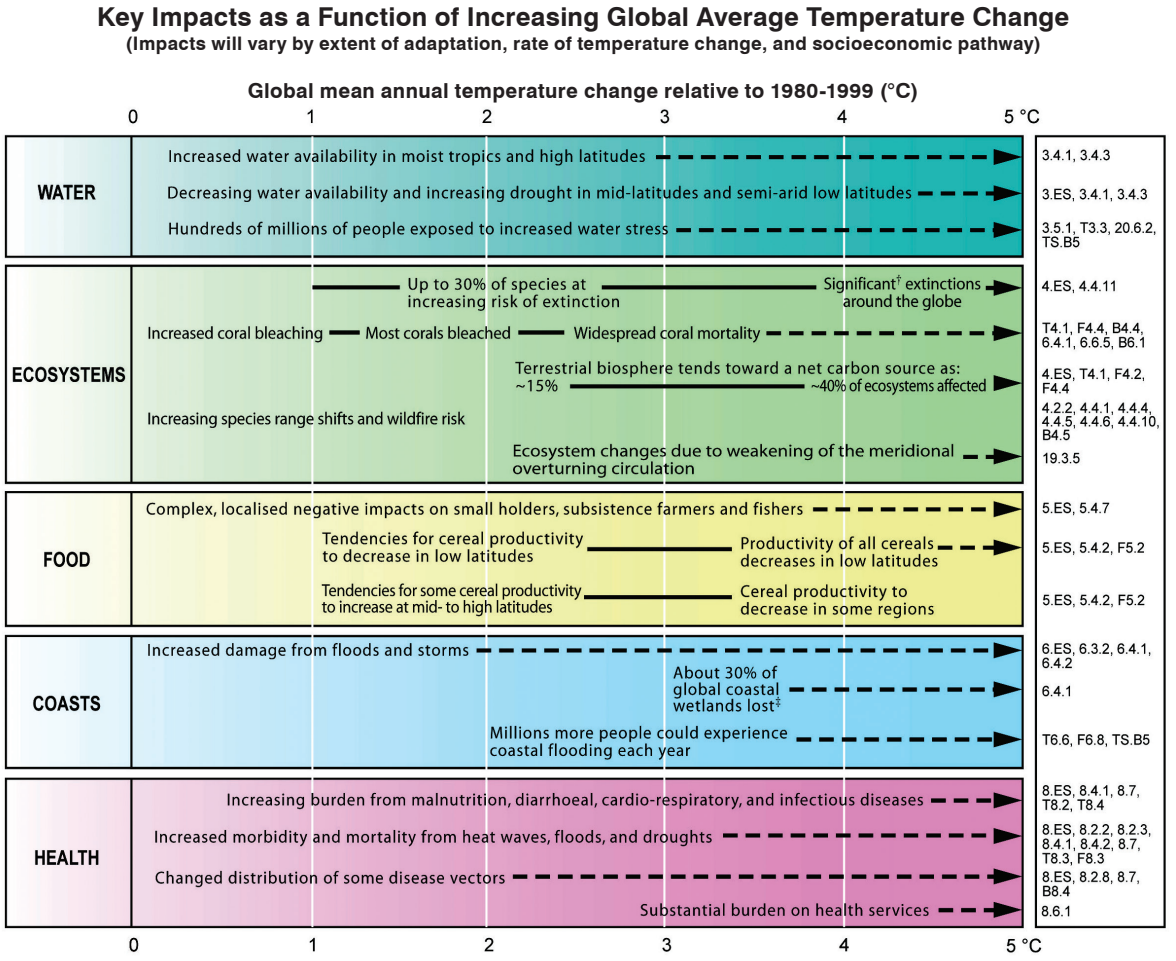
Joseph Tainter and Carole Crumley observe that today's approach to understanding global environmental change has been "largely hierarchical: authoritative, distant, and too often decontextualized. Our tendencies to develop abstract, aggregated models and to formulate international agreements exacerbate this problem" [13]. They argue that in addition to abstract models, it is essential that we undertake "locality-based studies of how people perceive their environments, transmit information, respond to external interventions, and recognize and accommodate change." Our research on adaptation scenarios in localities such as shrinking cities is responsive to the need Tainter and Crumley identify.

Adaptation and IT

Key opportunities exist for IT systems to support a high quality of life in these adaptation scenarios. For example, in the context of a future with reduced material abundance, IT may help organize and propagate knowledge about how to satisfy human needs in less materially intensive ways. IT systems may enable more effective utilization of resources via systemwide efficiencies, resource sharing, and acts of substitution and elimination. In addition, IT may also help people maintain and expand interpersonal relationships, rather than relationships with objects, thereby reducing material demands.

IT systems could also help foster new kinds of communities, such as transition towns. Educational IT systems can provide the scaffolding through which individuals and groups adopt new behavioral patterns. Technologies such as 3-D printing can enable these communities to create novel artifacts that work well with their changing needs. And communication systems such as FreedomBox and the SolarMESH project may help these communities maintain control over the informational infrastructures that connect them at civic, national, and international levels.

It is worth noting that these potential, adaptation-related IT interventions may be offset (or even more than offset) by



▸ Figure 1. Illustrative examples of global impacts projected for climate changes (and sea level and atmospheric carbon dioxide where relevant) associated with different amounts of increase in global average surface temperature in the 21st century. The black lines link impacts; dotted arrows indicate impacts continuing with increasing temperature. Entries are placed so that the left-hand side of the text indicates the approximate onset of a given impact. Quantitative entries for water stress and flooding represent the additional impacts of climate change relative to the conditions projected across the range of Special Report on Emissions Scenarios (SRES) scenarios A1FI, A2, B1, and B2 (see Endbox 3). Adaptation to climate change is not included in these estimations. All entries are from published studies recorded in the chapters of the Assessment. Sources are given in the right-hand column of the Table. Confidence levels for all statements are high. Source: IPCC [5].

other advances in IT that lead to greater resource consumption and the furthering of business as usual. Ultimately, successful adaptation will be a cultural transformation rather than solely a technological one. If this cultural transformation takes place, though, it is likely that IT will be influential in how it unfolds.

Domestic Plant Guild Project

One particular research effort that highlights the role that adaptation informatics could play is the Domestic Plant Guild Project. (For a more complete description of the project, see [14]). This project seeks to enable human communities to build robust relationships with ecosystems of native species. In modern times, understandings of native species have waned as irrigation, pesticides, and other tools and techniques have enabled farmers and gardeners to support plants outside their native ecosystems. In many global-change scenarios, the resources required to support non-native plants are likely to dwindle. The resulting threat of plant loss

in many landscaped and agricultural locations could possibly be addressed by reintroducing local knowledge of naturally thriving species. The need for these species to coexist with and support human populations represents a significant environmental challenge; for example, those species may not be considered aesthetically pleasing, or they may be endangered and difficult to propagate.

Several co-authors of this article are collaborating on the development of a sociotechnical infrastructure to foster adaptation to global change and to preserve native species through computationally supported plant guild design. Plant guilds are low- to no-input (i.e., no irrigation, fertilization, pest management) human-designed collections of various plant species that form viable ecosystems appropriate for a particular local climate, geographic location, and social context. A well-designed and appropriate plant guild can be an alternative to a garden and should provide people with useful products such as food, medicinals, and building and household materials that are becoming harder to produce sustainably.

Typically, designing a plant guild requires expert knowledge, as an intimate understanding of complex relationships between plants and their environment is necessary. The main technological focus of this project is the development of a Web-based application called the Plant Guild Composer (PGC), which supports non-experts in plant guild design. The PGC's primary role is to ensure that a valid design is produced in the context of the user's wants and needs. A valid plant guild design is reached once the needs for each plant in the guild (e.g., water, nutrients, sun exposure) are fulfilled by the environment and the other plants within the guild. The PGC elicits from the user relevant information, such as the geographical site where the plant guild will be located and the user's preferences regarding the characteristics of the plant guild, and then guides the user through the process of assembling an appropriate group of species. The PGC is not a fully automated tool, but instead an interactive design and implicit learning experience. When the user is prompted to select a plant to fulfill one of his or her needs (e.g., salad greens), the PGC will provide only plant choices that are compatible with the site location and other plants already chosen for the guild.

Like experts in plant guild design, PGC users who design, build, and use a plant guild will form an intimate relationship with their environment and the products they use in their lives, and thus should be equipped with practical knowledge for adapting to global change. Deriving its information from a custom-made, expert-supported database, the PGC serves to bridge the gap between the desire to create a locally relevant plant guild and the knowledge required to do so effectively. Additionally, the PGC has the opportunity to be more than a design tool; it can strengthen a sense of community ownership by letting users share their experiences via an online community. It can increase longevity of knowledge of how to build, design, and use plant guilds by giving users creative control within the computer-aided design process.

What if Humanity (Somehow) Addresses Global Change Without the Need for Adaptation?

As has been proven time and time again across history, humans have a remarkable supply of ingenuity. Therefore, humanity may well avert dramatic global change through a new energy source, geoengineering, or some other as yet unconsidered approach. If adaptation is rendered irrelevant, won't the research proposed in this article have been wasted?

We argue the work will *not* have been wasted, for two reasons. First, adaptation informatics has much in common with other HCI work. The overlap among projects and approaches among these genres makes a large portion of any research findings that may arise broadly relevant.

To offer a specific example, following publication of the results of the World3 model in the widely circulated *Limits to Growth* [15], the Bariloche Group of Latin American systems modelers offered the following critique: "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" [16]. Given these crises, a subset of adaptation informatics research efforts may be usefully adapted for application in other cultures and contexts in the present.

Second, one of the key concepts of adaptation informatics is designing sociotechnical systems with basic human needs at the heart of the process (see [17]). Many research projects and commercial undertakings focus instead on perceived needs or manufactured needs, which then leads to a proliferation of complexity in many people's lives. This complexity not only hastens progress toward societal collapse [18], but it also potentially compromises human quality of life. Humans evolved to deal with much narrower suites of issues than

those that currently confront us [19]; the vast complexity of many people's lives may contribute to a lack of societal well-being via cognitive overload [20]. By seeking to foster more direct paths to meeting human needs, adaptation informatics may also find new ways to make people happy.

Conclusion

This article is based on the possibility that global change is imminent, and that industrial civilizations may need to adapt dramatically in the coming decades, rather than indefinitely continuing the growth that has been its hallmark for much of the past two centuries. We propose that it is now appropriate for HCI researchers to begin exploring how our discipline may help to address the problems that would likely arise in such scenarios.

Work in these areas would seek to serve basic human needs, situated in particular contexts and habitats. There are many efforts afoot across many disciplines to enable sustainability; however, these efforts are often diametrically opposed to the culture of growth and consumption that pervades industrialized society. Perhaps by thinking now about life after global change, humanity may avoid some of the worst consequences of those transformations. Modifying a quote from John Michael Greer, "Adapt now and avoid the rush" [21].

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