Sustainability

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Abstract

Research needs in sustainability encompass a range of topics spanning much of social and behavioral science. Sustainability requires understanding human cognition, capacity to reason and make decisions, capacity for long-term planning, understanding trade-offs, risk perceptions, communication techniques, innovation, the consequences of improvements in efficiency, energy and other resources, complexity in problem solving, and other matters. We discuss research accomplishments and needs in the four most important areas of sustainability: (i) risk perceptions; (ii) influencing behavior; (iii) resources and economics; and (iv) problem solving and complexity.

INTRODUCTION

Sustainability has moved into mainstream discourse, so that the term *sustainable* has become like a Rorschach test. People project onto it whatever issues concern them. "Sustainable" is now applied to everything from Middle East ceasefires to eye shadow and Facebook. The term *sustain* comes originally from the Latin *sustinere*, and into English through the Old French *soustenir*. Both terms mean literally "to hold underneath"—in other words, to uphold or support. The *Shorter Oxford English Dictionary*, sixth edition, lists nine definitions of "sustain." Two of these read "Cause to continue in a certain state; maintain at the proper level or standard" and "Support life in; provide for the life or needs of." Both definitions are consistent with the original Latin and French terms: to sustain something is to support its continuation.

Vagueness in the term *sustainable* requires that specific sustainability goals be articulated. We use sustainability here in the sense that is intended by those concerned about humanity's future, and the relationship of that future to resources. Sustainability concerns the future sufficiency of the resources needed to support the diverse ways of human life, and people's resilience in pursuing those ways of life. Sustainability research potentially involves all of social life, and all resource use. We concentrate here on the following, highest-priority topics:

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Risk Perceptions. Many previous societies proved unsustainable and collapsed. Yet there is a widespread belief that contemporary societies have overcome this threat. Concern for sustainability requires that people recognize the risks of unsustainability. Such risks may come from resource depletion, overpopulation, pollution, climate change, unsupportable complexity, or other factors. Extensive discourse on these threats has barely changed behavior. Responses to risk are compromised by the tendency to discount future probabilities. Progress requires that we understand better how people recognize risk, discuss it, and act on it.

Influencing Behavior. Projections of the future are abstractions. People seem unwilling to change current behavior (such as consumption habits) based on abstractions. The immediacy of daily life is more compelling than the—perhaps distant—future. Yet that future is being shaped today. Emerging research is addressing questions about how to use communication tools to influence consumption decisions and related behaviors.

Resources and Economics. Resource consumption and technical innovation lie at the heart of sustainability issues. Particularly in recent centuries, societies have overcome resource limitations through innovation, improving the efficiency of using resources, or developing new ones. While risk perceptions and communication tools can change consumption habits, prices are considered the fundamental incentive. We do not know if innovation can overcome constraints forever, making it important to understand how innovation comes about.

Problem Solving and Complexity. The factors that make a society sustainable or not emerge over the long term, periods of decades to centuries. Solving problems today sets the stage for other problems in the future. Problem solving generates complexity and costs that can make a society unsustainable, as happened to some past societies. Finding ways to evaluate the effects of added complexity will be critical to sustainability efforts.

FOUNDATIONAL RESEARCH[1]

Risk Perceptions

The term *risk* is commonplace, but as with "sustainability" it varies and depends on the context and agents involved. The concept of risk has roots in maritime trade, financial speculation, and actuarial science developed to protect investments. In the late twentieth century, environmental damage and disasters exposed new facets of risk. Risks that threaten our ways of life are often hypothetical, involving new or rare hazards, and a great deal of

1. More extensive discussions of the issues discussed in this section, and the next, can be found in the list of suggested readings.

uncertainty. Those who bear the costs of risk can be distant in both time and place from the decision maker.

Risk perception is the judgment of risk. It depends on intuitive, experiential, emotional, and cultural factors, which contribute to the heuristics and biases we use when evaluating risk. Risk *perception* contrasts with risk *assessment,* the scientific and professional estimates of risk. Risk perception and assessment can result in disparate conclusions. Researchers seek to clarify the factors contributing to widely varying perspectives on risks.

Initial efforts to understand risk perception in relationship to sustainability were largely theoretical. To mediate temporal aspects and create a long view of risk, the potential for harm to future generations has been introduced into decision-making. The precautionary principle has been developed, and in some cases adopted into policy, to direct a course of action when science is compelling but uncertain, and risk is high.

Early empirical research focused on subjective and psychometric aspects of risk. Sociocultural and demographic differences influence risk perceptions. Psychometric researchers found that beyond the technical risk measures of probability and magnitude, factors influencing perceptions include dread, familiarity, voluntariness, visibility of effects, immediacy, severity, and numbers affected.

Influencing Behavior

Research in sustainability-oriented behavior is prevalent in the natural resources, business, psychology, and communications fields. This research originated with questions of why certain individuals are inclined to act in an environmentally sustainable manner, and whether we can use that research to influence others.

Studies traced human worldviews or values, and differentiated biospheric, altruistic, and egoistic value orientations. Value orientations have helped explain attitudes, and serve as predictors of behavior. Communications based in core values should elicit environmentally sustainable behavior. In close relation to human value orientations, studies also emerged investigating whether individuals practiced sustainability-oriented behaviors because of motivations that are extrinsic (such as financial incentives) or intrinsic (because it felt like the right thing to do). Normative research (observation and replication of behavior) measured the impact of influential others, such as family, close friends, or neighbors, in decision making. Experiments tested the impact of communicating percentages or numbers of similar others engaged in a behavior, such as whether one would turn off a shower to lather in a public swimming facility if another does, or shut off the engine in a traffic jam once others did. The question then arose how innovations

diffuse through society, exploring who the leaders, change-agents, or innovators are, and how they influence the majority.

In addition to values, motivations, and normative influences, strong connections were found between significant life experiences, such as an influential teacher or commercial development of one's hometown, and decisions to pursue careers dedicated to the natural environment. Research recently transitioned from explaining and predicting sustainability-oriented behaviors, and analyzing tools and message framing, to fostering lasting and large-scale behavior change.

Resources and Economics

The branches of economics most directly connected to sustainability—growth and behavioral economics—have produced literature that is indirectly useful. Environmental and energy economics are also relevant. The dominant perspective in growth economics, endogenous growth theory, places the generation and exchange of ideas (knowledge) as the principal driver of economic development. Understanding the diffusion of ideas is also pertinent.

Ideas, in contrast to other types of economic goods, are nonrival (the cost of providing an idea to an additional consumer is zero) and nonexcludable (it is difficult to prevent non-paying consumers from using the idea). The production of nonrival goods seems to defy the law of diminishing returns. Endogenous growth theory has had an indirect bearing on sustainability discussions as it supports the claim that humans can always innovate to overcome resource challenges.

Sustainable paths of socioeconomic development will ultimately require a change in consumption behaviors. The approach favored by economists is to rely on prices and incentives. The price elasticity of demand for a particular good or service (peoples' responsiveness to a change in price) can be used to estimate, for example, how much the price of fuel would have to increase before consumers significantly reduce driving. But the transition to a sustainable economy must involve more than price responsiveness. Citizens would have to make choices about risks and payoffs, and opportunities and costs. More ambitiously, citizens would need to envision living in a context in which increasing wealth is not manifested in more consumer goods. Research in behavioral economics (which studies the effects of social, cognitive, and emotional factors on economic rationality) shows that individuals find it difficult to assess risk, evaluate rewards, perform discounting, compare cost and benefits, and engage in probabilistic reasoning.

Problem Solving and Complexity

Sustainability programs should begin by asking four questions: (i) Sustain what? Sustainability is a common term, but people often do not specify what they want to sustain. (ii) Sustain for whom? At least in the short term, sustainability actions may promote winners and losers, thus generating conflict. This is exemplified in the debate over climate change. Conflict generates complexity (in managing and adjudicating it) and increases costs. (iii) Sustain for how long? Sustainability depends on specific social, economic, and environmental contexts. As these change, sustainability goals must change also. (iv) Sustain at what cost? Solving problems requires resources, and historical societies that achieved sustainability mainly did so by increasing complexity and resource consumption. Even if sustainability comes through simplification and conservation, there are opportunity costs. People would need to forego desired consumption.

Sustainability emerges from success at solving problems. Yet actions to promote sustainability can generate further problems. Human societies grow increasingly complex as they address problems, including challenges of sustainability. Complexity consists of differentiation in structure (more kinds of parts in a system), and greater organization (behavioral controls) to integrate the parts. This is evident in such spheres as technology, social and political roles, institutions, the economy, and information processing. Increasing in complexity to solve problems is exemplified in the growth of US government agencies and behavioral constraints following the terrorist attacks of 11 September 2001. In the technological realm, problems of pollution and fuel consumption in transportation are addressed by developing automobiles with two propulsion systems, where previously one was sufficient. Increasing complexity carries a metabolic cost. In human societies the cost of complexity is paid by money, labor, and time, all of which are surrogates for energy. Past societies that overcame sustainability challenges increased complexity and resource consumption, yet over time the costs undermined further sustainability.

CUTTING EDGE RESEARCH

Risk Perceptions

Increasing information does not lead to better understanding of risks, and may be counterproductive. Statistics do not overcome the propensity to believe one is less likely than average to experience negative outcomes. When there are conflicting risk messages, people select the information that fits previous beliefs. Scientific uncertainty is confusing or counterproductive, often resulting in mistrust. Appraisals of trustworthiness are made

of decision makers, regulatory agencies, risk initiators, communicators, and scientists. These appraisals affect public willingness to accept risk assessments.

Risks are not independently evaluated. Assessments are heavily influenced by perceptions of benefits. When benefits are potentially high, risks are perceived to be lower. Positive and negative emotional content makes risk information more salient.

Cultural theory proposes that perception of risk is related to constructed values and norms. Cultural cognition of risk blends psychometrics with the cultural theoretical approach, explaining perceptions of risk within a cultural perspective. It explores failures of science to influence opinion about controversial issues.

The social amplification of risk framework (SARF) integrates risk-related research into a unified approach to the understanding of risk perception, risk communication, and social responses to risk. SARF proposes that in reacting to a risk, social interactions influence perceptions and risk-related behaviors, which lead to institutional responses and protective actions. The effects ripple outward to individuals, groups, and institutions, creating change.

Influencing Behavior

Earlier practices involving connecting values, enhancing knowledge, altering attitudes, and understanding normative influences were found to be insufficient to change behavior. New tools and techniques are therefore being developed to influence behavior, based on how values, attitudes, and norms guide people. One of the leading sets of tools in this area is community-based social marketing. This promotes change by targeting behaviors, identifying perceived and actual barriers and benefits, developing strategies to overcome barriers and increase benefits, pilot testing an action plan, implementing the plan on a broad scale, and finally, evaluating impact. Within this approach, a targeted action plan has been proposed to foster behavior change. This plan includes:

- Developing effective communication tools (e.g., repetitive messaging, catchy phrasing, appealing terminology, and design).
- Establishing norms (e.g., displaying behavior and sharing statistics of how many local, similar people are engaged in the behavior).
- Using prompts placed as close to the target behavior as possible (e.g., cashiers handing out grocery lists that state "bring bags" at the top, or printing messages on disposable cups that there is a discount if customers bring their own mugs).
- Providing and marketing incentives.

- Gaining commitment (e.g., actions ranging from a handshake to a public pledge).
- Removing external barriers (e.g., providing information on what is recyclable by creating a poster illustrating what can be recycled, and placing the poster on or near the bin).

Other marketers are looking at ways to appeal to the public, through approaches such as "making green more macho." One example is the "Don't Mess with Texas" anti-littering campaign. Branding involved masculine messaging and connecting with Texans' core value of independence. This campaign is recognized worldwide as one of the most successful environmental campaigns, reducing highway litter within the first 15 years by 72%.

Communication using popular technology (e.g., Facebook, Twitter, blogs, Pinterest, web sites, YouTube, apps, and Ted Talks) is being explored as a way to reach youth. Environmental topics ranging from upcycling, to urban farming, to sustainable seafood systems, have had over a million views on pertinent web sites, and are connecting a sustainability community larger than the environmental movement. Many now claim that we have reached a "tipping point" in public interest.

Resources and Economics

Standard economics suggests that, to change behavior, one must change incentives. Most public policy is based on this view, which assumes that people operate purely as individuals, and that they systematically compare the costs and benefits of alternatives. Within this theory, individuals then make the best choice for themselves. Policy is therefore based on changing the incentives that people face, altering the costs and benefits of different choices. This approach is not wrong but it is only partial. We now know that individuals' preferences, choices, and assessments are affected by their social networks, much as are perceptions of risk and susceptibility to communications. Ideas and behaviors either spread or are constrained within networks. Early adopters are especially important in influencing behavior. Incentives matter, but could be of secondary importance compared to the influence of peers. Research is developing ways to identify the strength of network effects versus individual selection on behavior, classify the network topology and how it affects behavior, and develop strategies to alter behavior within network effects.

Problem Solving and Complexity

Humans first use the resources that are easiest to find and produce. In time, this forces exploration and production to shift to resources that are deeper,

more remote, difficult to extract, or occurring in lower concentrations. This process is evident in petroleum production. The profitability of an energy source is given by its ratio of energy returned to energy invested (EROI). In 1940 the United States produced oil and gas at an EROI of 100 : 1. This has now declined to about 18 : 1. EROI of oil shale production is below 2 : 1, while for Canadian tar sands the figure is between 4 : 1 and 2 : 1. Both sources are energetically feasible only because production uses on-site natural gas to free the oil. Renewable energy sources also have low EROI. Photovoltaic energy in Spain has an EROI of 2.45 : 1. EROI below about 8 : 1 causes the energetic profitability of energy production to plunge rapidly. As EROI declines, more complex and costly technologies are needed to find and produce energy. Finance may become a constraint to energy production. Complex technologies are prone to accidents, as evident in the Deepwater Horizon blowout of 2010.

Many argue that technological improvement will reduce energy use per unit of economic output, and improve the profitability of resource production. As the easiest technical questions are answered, however, science grows more complex and costly, and produces diminishing returns. From 1974 to 2005, the productivity of research (measured as US patents per inventor) declined by 22%. This suggests that efficiency improvements cannot forever offset resource depletion, as research will eventually become too expensive and unproductive. The energy sector, including renewable energy technologies, has seen declines in research productivity.

Increasingly complex problems require increasingly complex solutions, which are more costly in money and resources. Since problems are inevitable, it will be difficult for societies to constrain their resource consumption voluntarily over the long term.

KEY ISSUES FOR FUTURE RESEARCH

Risk Perceptions

Risk perceptions research contributes to overall knowledge, but neglects important aspects of the particular concerns of sustainability risks such as long-term prospects, cumulative effects, and consequences to others. We need to understand how to align the risks of actions or non-actions in the present with the values held for the future, especially when evaluations must overcome the appeal of financial or other benefits in the present.

Sustainability is not well served by existing models of risk behavior that indicate what people should do or what people actually do. This includes such approaches as economic risk analysis, game theory, and prospect theory. Economic models of risk perception do not account for alternative motivations, such as altruism, and suggest, contrary to evidence, that additional

information should alter peoples' perceptions of risk. Game theory predicts what people do (and/or what they should do), but it presumes rationality and neglects social factors that are important in sustainability. Prospect theory applies when probabilities are known, but in sustainability matters they usually are not. The explanatory value of current risk perception models remains low to moderate for individuals, requiring additional research.

Because the things people fear are not always the risks they act on, research is needed to understand what motivates people to respond to technological and environmental risks. One factor to be investigated is the role of emotion in risk evaluation and communication. Perceptions of risks which have complex or multiple causes, long latency, or compounded effects have also been insufficiently explored.

Some critics assert that individuals are left to evaluate and cope with risk alone, lacking social support, adequate understanding, and accurate information. There is a need for further investigation into what constitutes a trustworthy source of information, as well as the effects of trust and credibility in risk perception.

Scientists, policy-makers, and laypersons use different rationalities in their assessments of risk. They have different methods and requirements for establishing knowledge. This creates confusion when specialists communicate among each other, and with the public.

Mass media shape the experience and perceptions of risk. The processes and effects of media are critical to SARF, yet they have been incompletely explored. The role of new communication technologies (see above), and the loss of traditional forms of media, present opportunities to investigate changes in social amplification processes. Finally, it will be important to evaluate the cross-cultural and international applicability of the research findings and models of perceptions of risk. In summary, important research questions include:

- What factors influence perceptions of risks that motivate people to action?
- How can we encourage long-term risk perspectives that are based in values we wish to project into the future?
- How can scientists and policy makers communicate about the uncertainties of risks and weigh them against known benefits in ways that promote future sustainability?
- What are the processes and effects of mass media and new media in creating and influencing perceptions of risk?
- How does context shape risk perception and response among different cultures and nationalities, and what can be learned from such variation?

Influencing Behavior

Behavior changes can be fostered at levels ranging from individuals to households, communities, and societies. Effective communication is necessary to establish buy-in and behavior change at all levels. Lack of effective communication allows opposition to emerge. Social scientists have established an excellent theoretical foundation and set of marketing tools for fostering individual, household, and community change in sustainability-oriented behaviors. There is still a gap, however, in fostering change on a larger scale. This includes government, large corporations, and our education system. At the societal level researchers are investigating aspects of the communication process that have led to wide-scale resistance to the climate change message. Can new communication tools help change behavior?

There are many examples of effective communication at the individual level. Concerns about our food production system, for example, inspire people to try innovative ways to grow and harvest food. This is no longer a movement for affluent, upper-class citizens; at-risk youth are joining urban farms such as "Brother Nature" or "Grow Power." This movement, and other examples, prompt a series of broad-scale research questions, as follows:

- How can we align environmental messaging with specific cultural groups to foster cross-spectrum commitment? Can we effectively and efficiently find connections in culture and terminology, and use these to design tools and messages that can bring about lasting change?
- How do we successfully facilitate institutional change, resulting in nation-wide impacts?
- How can various types of social media be used to foster environmentally sustainable behavior? How do we measure whether there is an association between a message and a behavior change? What are the best tools to reach a large audience and foster change?
- What influences whether people engage such things as sustainable food systems, recycling, or other activities? What are the restrictions to these influences?
- What models and messages about sustainability work best in different social and geographic settings?

Resources and Economics

The generation, recombination, and exchange of ideas are the main drivers of economic growth. These are also major factors in achieving sustainability. Work by Charles Jones and Paul Romer indicates that there is a virtuous cycle for economic growth between population size and the generation of

ideas. Larger populations have a larger repertoire of intellectual capabilities, thereby facilitating the creation and recombination of ideas, including ideas related to sustainability. This process can lead to technological, organizational, and cultural innovations that underpin wealth creation and the ability to sustain larger populations.

Every human endeavor, including the creation of knowledge, requires energy. Energy is the basis of wealth, knowledge creation, and sustainability, yet we know little about the energetics of innovation. It is important also to understand how the innovations induced by increasing population and the energy needs of an increasing population interact with and mediate each other. We suggest the following topics for future research:

- Is innovation more productive or efficient in respect to energy use at the aggregate, societal level than at the level of the individual inventor? Do interactive effects in innovation produce increasing returns relative to the energy cost of innovative activities? What, in other words, are the energetics of social knowledge creation?
- We know at the level of the individual person or firm that the generation of ideas exhibits diminishing returns, but there are reasons, both empirical and theoretical, to think that at the societal level, through positive externalities, it does not. The conditions under which these externalities operate, however, may not be self-perpetuating. Are there, in fact, increasing returns to research at the societal level?[2] How, in this context, do we disentangle research and development, invention, and idea creation, which are all different aspects of the innovative process?

Problem Solving and Complexity

Sustainability requires thinking about the long-term future, an abstraction that competes poorly with current material consumption. The inclination to think and act in regard to the future varies with culture and language. In our history as a species, evolution did not select for concern about the distant future. People generally think in terms of the immediacy of their daily lives, perhaps planning for such matters as retirement and their children's education. In the time scale of societal sustainability, such matters are short term. Sustainability requires shifting thinking from what Daniel Kahneman calls System 1 (automatic, culturally-conditioned thinking) to System 2 (rigorous, analytical thought). Thinking in System 2 is difficult. It requires conscious effort, on a continuing basis. In short, to be sustainable requires modes of thinking that do not come easily to many people.

2. Even though research investments seem to produce diminishing returns in innovations per inventor (see above), the ideas generated may produce increasing returns in the economy.

Several analyses suggest that economies cannot grow forever, or even continue indefinitely at current rates of resource consumption. The solution commonly proposed is to reduce resource use by voluntary conservation, by innovation producing greater technical efficiency, or by some combination of these. An alternative, common in economic reasoning (see above), is to allow rising prices, resulting from resource scarcity or increasing costs of procurement, to curtail consumption. Yet as the British economist William Stanley Jevons pointed out in the nineteenth century, conservation and efficiency reduce the cost of resources to such a degree that consumption actually increases. This is known as the *Jevons Paradox*, or the *Rebound Effect*. For example, as Americans began to drive more fuel-efficient cars in the 1970s and 1980s, they responded to greater fuel economy by driving more miles. It has been suggested that the Rebound Effect can be counteracted by taxing savings from increasing efficiency. But any use of such savings—consumer spending, investment, or government spending—consumes resources, as Jevons would have predicted.

There is also the matter of complexity, and the resources that it requires. Sustainability, as noted, results from success at solving existential problems, and problem solving generates increasing complexity. Sustainability is not free. It takes resources to solve problems, and past societies achieved periods of sustainability by increasing their resource consumption. The alternative is not to solve societal problems, but this involves opportunity costs. We can expect problems in our own future, requiring resources to solve. Yet sufficiency of resources is precisely the problem we expect to face. In addition to the Jevons Paradox, which suggests that technical innovation does not save resources, there is the further dilemma that the productivity of innovation investments is declining. As we address the easiest scientific questions, those next in line become more challenging to resolve, requiring larger research teams, greater complexity, and higher costs. This produces diminishing returns. If the trend of declining productivity of research continues for another generation, solving sustainability problems through technical innovation will become unproductive and unaffordable.

These conundra are the essence of whether we can have a sustainable future. They suggest the following topics for future research:

- Can the human inclination to think short-term, and in System 1, be overcome by early childhood education? Can children (or enough children) be taught to think in ways that for many people do not come automatically? Addressing these questions would require longitudinal studies of the kind done in some medical and other research.
- Can increasing efficiency in resource use be decoupled from saving money, thereby circumventing the Jevons Paradox?

- Can major societal problems be addressed without increasing complexity and resource consumption? Is it possible to simplify and consume less, yet meet existential challenges and continue a desired way of life? These questions can be addressed in part by historical research, focusing on case studies that illustrate general ways that humans solve problems.
- Is it possible to produce the material standard of living that people currently want, including economic growth, while reducing resource consumption and while also avoiding both the Jevons Paradox and further complexity?
- Can technical innovation continue to overcome resource constraints under diminishing returns to research inputs?

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Temis G. Taylor earned her MS in Bioregional Planning at USU and is currently pursuing a PhD in Human Dimensions of Ecosystem Science and Management under the direction of the lead author. Interest in social aspects of sustainability, perceptions of risk, and construction of knowledge in relation to energy development drive her current research.

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Roslynn G. Brain is an Assistant Professor in Sustainable Communities at Utah State University. She uses conservation theory, communication techniques, and social marketing tools to foster a broad spectrum of environmentally-sustainable behaviors, with a focus on waste reduction and local food movements. Roslynn developed and launched Extension Sustainability (http://extension.usu.edu/sustainability), a set of tools and information for the general public to engage in sustainability-oriented behaviors. She also teaches Communicating Sustainability at USU, helps coordinate the University's annual Earth Week, and has launched a statewide program to connect farmers with restaurants, called *Utah Farm-Chef-Fork*. She designed and co-teaches a summer sustainability camp for children in Utah.

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