
Higher education as a change agent for sustainability in different cultures and contexts

Higher education
as a change
agent

317

Jennie C. Stephens

*Department of International Development, Community, and Environment,
Clark University, Worcester, Massachusetts, USA*

Maria E. Hernandez

*Centro de Ingeniería Ambiental, Universidad Tecnológica Nacional,
Regional Tucumán, SM de Tucuman, Argentina*

Mikael Román

Stockholm Environmental Institute, Stockholm, Sweden

Amanda C. Graham

*Education Office, Energy Initiative, Massachusetts Institute of Technology,
Cambridge, Massachusetts, USA, and*

Roland W. Scholz

Institute for Environmental Decisions, Zurich, Switzerland

Received 1 March 2008
Revised 12 March 2008
Accepted 27 March 2008

Abstract

Purpose – The goal of this paper is to enhance consideration for the potential for institutions of higher education throughout the world, in different cultures and contexts, to be change agents for sustainability. As society faces unprecedented and increasingly urgent challenges associated with accelerating environmental change, resource scarcity, increasing inequality and injustice, as well as rapid technological change, new opportunities for higher education are emerging.

Design/methodology/approach – The paper builds on the emerging literature on transition management and identifies five critical issues to be considered in assessing the potential for higher education as a change agent in any particular region or place. To demonstrate the value of these critical issues, exemplary challenges and opportunities in different contexts are provided.

Findings – The five critical issues include regional-specific dominant sustainability challenges, financing structure and independence, institutional organization, the extent of democratic processes, and communication and interaction with society.

Originality/value – Given that the challenges and opportunities for higher education as a change agent are context-specific, identifying, synthesizing, and integrating common themes is a valuable and unique contribution.

Keywords Higher education, Change management, Sustainable development, Transition management

Paper type Conceptual paper



The authors would like to thank Jin Qian who was integrally involved in the initial discussion of this paper. Jennie Stephens would also like to thank John Holdren, William Fisher, and Halina Brown for their inspiration and support in considering this topic.

International Journal of Sustainability
in Higher Education
Vol. 9 No. 3, 2008
pp. 317-338
© Emerald Group Publishing Limited
1467-6370
DOI 10.1108/14676370810885916

1. Introduction

Human society is currently facing unprecedented challenges associated with our interactions with the earth's natural systems. Current trends and patterns of resource-use, coupled with a rapidly changing, increasingly unequal, complex and interconnected societal structure and rapid technological change, are impacting human-environment interactions in critical and unsustainable ways. This new era of intense, irreversible human influence on the earth's systems has been named the Anthropocene and has been defined as an epoch that began in the early 1800s with the onset of industrialization (Steffen *et al.*, 2007). Within the Anthropocene, the scale and intensity of human influence on the earth's systems has begun to threaten the sustained availability of basic human needs, including water, food, and shelter.

The sustainability challenges that human society is grappling with are increasingly urgent as the rates of change in many dimensions are accelerating. Given the urgency for confronting sustainability challenges in diverse and diffuse ways, opportunities are emerging for different societal stakeholders and institutions to engage in new ways. Institutions of higher education have a particularly interesting potential in society to facilitate societal responses to the plethora of sustainability challenges facing communities around the world.

This paper explores opportunities and challenges for institutes of higher education as agents for change in advancing more sustainable practices in different cultures and contexts. The paper identifies five critical issues to be considered in assessing challenges and opportunities in any particular region or place. To demonstrate the value of these critical issues, exemplary challenges and opportunities in different places are provided. The goal of presenting these issues is to facilitate social change in the development and expectations of institutions of higher education toward more deliberate societal engagement on the unprecedented and increasingly urgent sustainability challenges associated with rapid environmental change and increasing societal complexity.

1.1 *Environmental, social, and technical change and challenges*

The sustainability challenges that human society is currently facing are derived from and can be connected to three categories of changes and challenges:

- (1) environmental change;
- (2) societal change; and
- (3) technical change.

Climate change, biodiversity loss, deforestation, water quality degradation, and air pollution are among the categories of unprecedented and in some cases irreversible environmental changes that have been occurring. The influence and impact of human behavior and technology on the earth's environmental systems has been growing since the advent of industrialization over 200 years ago. Within the last 50 years, an acceleration of this influence is evident with drastic environmental changes observed in many domains (Steffen *et al.*, 2007).

In addition to environmental changes, the structure of human society has been changing dramatically; communication technologies and globalization have resulted in increasingly complex and dynamic interconnections within society. We are currently in a transition to a post-industrial service-society or information society. Society's

current social structure, the current economic world order, has resulted in changes of increasing global inequality, social injustice, and polarization. Higher education as a change agent

Technological change is another category of major change contributing to both the cause and the potential solutions of the major sustainability challenges facing society. Technological change associated with industrialization, personal mobility (the automobile), food production, and many others, are directly linked to irreversible environmental changes. In considering a transition toward sustainability, as society faces a doubling of food production and rapidly growing energy demands societal reliance on technical development is increasingly apparent.

The rates of change in each of these categories has been accelerating throughout the past 100 years; the current pace of changes in environmental conditions, the interconnectedness of human society, and technological innovation are unprecedented. The value of integrating the advancement of understanding of environmental, social, and technical change, integrating the study of human and natural systems, is increasingly being demonstrated and called for (Liu *et al.*, 2007).

1.2 Transition towards sustainability

While the word “sustainability” clearly allows some flexibility in its meaning and use as different interpretations and definitions of this word have been proposed by different individuals and institutions (Laws *et al.*, 2004; Marshall and Toffel, 2005; Martens, 2006), one common dimension of the word’s definition is related to time. Sustainability encompasses an inherent goal of being able to persist, sustain, and endure. To enhance societal capacity to persist and endure the scale of environmental and social changes currently being experienced, the development, fostering, and harnessing of new approaches and mechanisms for human life on earth are essential. A transition to a new pathway toward more sustainable practices and lifestyles is required. Such a transition is complex (Ravetz, 2006) and requires society-wide shifts in priorities and perspectives (Kates, 1995). And it is well recognized that managing these changes is an ongoing inquiry facing “ill-defined problems” and uncertainties (Laws *et al.*, 2004).

In responding to the need for a transition toward sustainability, the emerging literature of transition management provides a useful structure for examining the large-scale transformation of governance regimes in response to complex, long-lasting and multi-level societal problems. Transition management explicitly attempts to balance and integrate the importance of long-term goals and the crucial nature of short-term demands (Kemp *et al.*, 1998; Rotmans *et al.*, 2001; Kemp and Loorbach, 2003; Loorbach and Kemp, 2005). Grounded in complex adaptive system theory, transition management focuses on the complexity of transition and recognizes the interactions, interdependencies, and feedbacks between different actors, technologies, infrastructures, institutions, and governance systems (Kemp and Loorbach, 2003).

The transition management framework specifies three different levels of exploration of transition within an evolutionary frame: strategic, tactical, and operational, each of which involves different policies and actors (Loorbach and Kemp, 2005). The strategic level focuses on higher-level activities of leaders (government, business, non-profit) who engage in strategic visioning and discussions, laying out long-term goals and objectives and establishing the structure and context for the issue. The tactical level concentrates on agenda and coalition building, and negotiations

involving existing institutions and structures and transforming them to carry out the larger strategic goals. Finally, the operational level concentrates on project building and implementation, focusing on variation and flexibility (Loorbach and Kemp, 2005). These different levels interact, reinforce, and iterate throughout the processes of innovation. And both actors and institutions are recognized as both responding to change and as agents shaping change (Kemp *et al.*, 2007). To the authors' knowledge, the role of institutions of higher education through all of their activities, including teaching, research and broader societal engagement, has not yet been explicitly explored within the transition management literature. Yet, given the importance of higher education in society and the potential for mutual learning (Scholz *et al.*, 2000) higher education has unique potential to catalyze and/or accelerate a societal transition toward sustainability.

Given the diversity of activities that are associated with institutions of higher education, there are many possible mechanisms for institutions of higher education to contribute to social change and a sustainability transition. Higher education can, and is already in some places, contributing to sustainability social change in all three levels; strategic, tactical, and operational. At the strategic level, higher education can be involved in defining and developing strategic societal visioning and setting long-term goals. At the tactical level, institutions of higher education can foster and facilitate coalitions and cooperation among stakeholders (Scholz *et al.*, 2006). And at the operational level, higher education can implement change through the curriculum, research, their own campus-operations, and through mutual learning with society on specific challenges (Filho, 2000; Scholz *et al.*, 2000).

1.3 Institutions of higher education in the transition towards sustainability

Institutions of higher education hold a unique position in society. Institutions of higher education are critically important places of knowledge production, knowledge perpetuation, and knowledge dissemination. In addition to these conventional associations of universities and knowledge, institutions of higher education have unique potential to encourage synthesis and integration of different types of knowledge and to enhance the application of knowledge to social change.

With regard to a societal transition toward sustainability, the primary role of institutions of higher education can be viewed in two ways: universities can be perceived as an institution that needs to be changed or universities can be perceived as a potential change agent. The distinction between these two perceptions of the role of higher education is critical and not widely appreciated. Many considerations of sustainability in higher education assume the first of these two perspectives, and less attention has been paid to the second view focusing on the potential of higher education itself as a change agent. While Ferrer-Balas *et al.* (2008) and Svanström *et al.* (2008) focus on the first of these two views by focusing on how higher education can change internally, this paper explores the potential of institutions of higher education as a change agent in society, focusing on how higher education can facilitate change external to its own institutions.

Many different perspectives and expectations on the role, value and potential of the university in society translate into many different perceptions of opportunities for the university as a change agent in a transition toward sustainability. While these perceptions will vary in different cultures and contexts, there are four general

categories of perceptions on how institutions of higher education might contribute to the societal transition toward sustainability.

First, higher education can model sustainable practices for society; this view is based on the premise that sustainable behavior should start with oneself and by promoting sustainable practices in the campus environment, learning related to how society can maximize sustainable behavior is accomplished. Second, higher education teaches students the skills of integration, synthesis, and systems-thinking and how to cope with complex problems that are required to confront sustainability challenges. Third, higher education can conduct use-inspired, real-world problem-based research that is targeted to addressing the urgent sustainability challenges facing society. And lastly higher education can promote and enhance engagement between individuals and institutions both within and outside higher education to resituate universities as transdisciplinary agents, highly integrated with and interwoven into other societal institutions.

The first of these categories incorporates the view that the university is a microcosm of society that can try innovative approaches toward environmental management in their own campus operations (Ferrer-Balas *et al.*, 2007). Within this view, institutions of higher education have potential for influence by modeling sustainable practices internally in ways that all those who engage with the university will recognize, appreciate, learn from, and, critically, emulate. Thus the practices and the sustainability principles behind these practices in model universities are transferred to their partners via the partners' own external institutions and behaviors (Creighton, 1998; Barlett and Chase, 2004; Mulder, 2004; Rappaport and Creighton, 2007; Rappaport, 2008).

The second category incorporates the view that higher education is primarily a place of concentrated learning, and in that context the university could be, through its teaching and curriculum, promoting and advancing sustainability (Colucci-Gray *et al.*, 2006). A curriculum designed to promote sustainability does not only require a traditional knowledge base, but instead requires a new and emerging set of skills, perhaps most importantly skills requiring synthesis, integration, and appreciation of complex systems. Higher education, therefore, has potential to facilitate a societal transition by adjusting its curriculum to incorporate, reward, and support skills of synthesis, integration, and complex systems thinking. For example, while engineers have been traditionally taught how to build a bridge, society now needs engineers that not only know how to build a bridge but also are able to incorporate into the building of the bridge considerations about what is on both sides of the bridge, who might be using the bridge, when and why, and how the needs for the bridge may change over time. Strategic planning and understanding of the social infrastructure surrounding technological development is, in this new era, a critical part of engineering education. A broader societal context for understanding and interpreting the societal impact or significance of any technology, discovery, or disciplinary focus is now critical. This need for contextualization encompasses a new need for systems thinking and management of complexity and interconnections, and de-emphasizes the need for technological perfection or disciplinary narrowness.

The third category incorporates the view that higher education plays a unique role in society, in that institutions of higher education are places where independent and free-thinking research and idea-exchange is promoted and supported. Universities are

generally thought of as places for creating, maintaining, passing on, and exchanging knowledge. But given the societal urgency for a transition toward sustainability, a new conceptualization of both knowledge creation and knowledge exchange are required. With respect to knowledge creation, or research, there is a new need for use-inspired research, research motivated primarily by a desire to affect social change to move toward a more sustainable path rather than the more conventional research motivation of advancing the boundaries of knowledge and understanding as a creative and sometimes even self-indulgent activity. With respect to knowledge exchange, in this new era of sustainability challenges there is a new need for students to learn how to learn for themselves and in interaction with practice, not to expect to learn directly and primarily from their professors or teachers. The interconnectedness and complexity of the greatest challenges that society is facing calls on individuals to work collectively to understand the systems, so the notion of a single “teacher” or professor as an expert who can pass along knowledge to their students has lost some value. In this context, interdisciplinarity, activities that include a fusion of concepts or methods from different disciplines, plays an emerging critical role. Interdisciplinarity is required when coping with complex, real world problems or addressing topics that are too broad or complex to be dealt with adequately by a single discipline or profession (Klein and Newell, 1997).

And finally, the fourth category relates to the potential of institutions of higher education to integrate with and influence the rest of society by enhancing outreach, engagement, and interactions beyond the individual faculty, staff, and students who are officially affiliated with the institution. In this realm the possible mechanisms for enhanced linkages are varied, but include, for example, engagement in policy-making, non-formal education, community development and planning, and technology assistance. This external engagement is a fundamental to the concept of transdisciplinarity, a notion that goes beyond traditional disciplinary and interdisciplinary activities. Transdisciplinarity explicitly incorporates processes, knowledge and goals of stakeholders and organizes processes of mutual learning between science and society (Scholz *et al.*, 2000). So in addition to interdisciplinarity, higher education has potential to promote transdisciplinarity by enhancing engagement with stakeholders other than students, faculty and staff.

2. Identifying challenges and opportunities in different cultures and contexts

The potential for higher education to be a change agent accelerating a transition toward sustainability is dependent on a variety of factors including the current position, structure, and arrangement of higher education within its society as well as the location-specific sustainability challenges and opportunities facing a given community or region. Given the heterogeneity of sustainability challenges as well as the heterogeneity of societal expectations, values, and cultures impacting higher education in different communities and regions around the world, the authors describe five specific questions that raise five different sets of critical issues that are uniformly critical for considering the challenges and opportunities in any particular context. To demonstrate the variation in these critical issues in different places, the paper includes anecdotal examples from Argentina, the USA, Sweden, China, Germany, and India that

illustrate in a comparative yet synthetic way the importance of considering these five categories. Higher education as a change agent

The five questions include consideration of factors that are both internal and external to the higher education system, and provide a systematic approach to reviewing challenges and opportunities. The five questions relate to:

- (1) the dominant sustainability challenges of the region;
- (2) the financing structure and independence;
- (3) the institutional organization;
- (4) the extent of democratic processes; and
- (5) communication and interaction with society.

323

These five critical issues can be explored in the context of any institution or system of higher education throughout the world to assess the potential and limitations for higher education as a change agent. By considering these questions, empirical identification of location-specific characteristics can facilitate the design and implementation of new initiatives and new approaches to maximize the potential for higher education accelerating social change toward sustainability.

This section presents and explores these five issues by posing five sets of questions and explores the implications and relevance of each by identifying general challenges and opportunities and also providing explicit references to and examples of regional and national variation.

2.1 What are the dominant sustainability challenges? What are the social, environmental, and technical conditions of the region?

One critical component of considering the opportunities and challenges of higher education as a change agent for sustainability is the identification of location-specific sustainability problems, which includes the status and rate of change of socio-economic, technical, and environmental conditions of the region. The plethora of societal challenges that are linked to sustainability is broad and highly variable in different places around the world, so identifying region-specific social, environmental, and technical conditions is helpful to considering opportunities and challenges for higher education.

With respect to social conditions of a region, there are several critical dimensions to consider including economic factors including per capita personal income, wealth distribution, and economic structure, as well as social structure including the degree of religious, racial, and economic divisions. In many places throughout the world, low personal income and unequal distribution of wealth exacerbates environmental degradation and limits the capacity for transitioning to alternative pathways. In China, society is grappling with rapid economic development, including unprecedented growth in production, consumption, and buildings. In Argentina, an unequal society where a large portion of the people live in poverty without access to education or information, the economy is based primarily on agriculture and natural resource extraction (mining, oil, gas, deforestation). The social and economic conditions in China, Argentina, and many other places enforce a lack of political leadership and limit strategic long-term considerations of the sustainability of current practices. The opportunity exists, therefore, for higher education, a social agent that is uniquely

stable, independent, with a capacity for long-term thinking, to interact with political leaders and other stakeholders to counter the dominant economic and political tendencies to focus on near-term conditions and change.

Also embedded in the social conditions of a specific region or place are cultural attitudes and beliefs associated with the sustainability challenges and also cultural attitudes and beliefs associated with higher education. Cultural interpretations of sustainability need to be recognized (Thaman, 2002) particularly given that divisions exist within the education and science community on what “education for sustainability” actually entails (Wals and Jickling, 2002; Power, 2006; Maclean and Ordonez, 2007).

With respect to environmental conditions, although the dominant environmental challenges are generally global problems, i.e. climate change, deforestation, water availability, the impacts of these dominant challenges manifest themselves in very different ways in different places. For example, the potential for a university in Bangladesh to facilitate positive change with respect to climate change impacts is going to be very different than the potential for a university in Japan or the United States to facilitate change with respect to climate change impacts. In Bangladesh, engaging with communities to develop adaptation strategies for forced migrations due to flooding from rising sea-levels is likely to be a valuable activity for universities. In Japan, the USA or other energy-intensive, high-carbon emitting societies with high per capita consumption, universities have a very different potential to facilitating society-wide changes by strengthening climate change mitigation efforts by reducing carbon emissions through promoting climate policy development, fostering behavior change, and advancing low-carbon emitting technological change.

With respect to technological conditions, variation in the status and rate of change in technology is huge, and has major implications for considerations of higher education as a change agent. Higher education can play a role in advancing renewable energy technology throughout the world, but potential strategies for accomplishing this will vary in different places. For example, in regions of the world with limited electrification, higher education can play a role by demonstrating and supporting the adoption of solar panels or solar cookers. In other countries higher education can play a role by engaging with regional renewable energy businesses and working toward developing public policies that are favorable to renewable energy technology adoption.

Returning to the example of Argentina, the dominant sustainability challenges include huge social inequality, massive deforestation for soy agriculture, chaotic urbanization and new infrastructure construction without concern for associated environmental degradation, water and air pollution, and vulnerability to climate change impacts. The lack of political movement to combat these challenges is very clearly embedded in a short-sighted political context where influential and powerful individual stakeholders often control the political agenda as well as the media and the extent of information dissemination. In this context, universities have the challenge of working within this political environment, but they also have great potential to influence positive change by providing unbiased and clear information to politicians, industry leaders, and the public, by identifying long-term negative impacts of the status-quo processes and approaches and by providing visions and methods for alternative, more sustainable paths.

2.2 *How is higher education financed?*

The financing of any particular higher education system or institution has direct implications on the potential for a university to advance sustainability. Global trends in financing higher education include a decreased capacity for government, or public money, to finance the increasing demand for higher education and an increased pressure for universities to obtain external private financing. In nearly all countries there has been tremendous growth in student enrollments; this growth is exceeding the capacities of governments to supply enough higher education for all who are demanding it (Braddock, 2002; Mendivil, 2002).

A general trend towards more market-based funding mechanisms to support universities can also be observed all over the world. This shift toward more private institutions and less public support, has enabled the emergence of new actors and interest in education and research, challenging the previous notion of higher education and publicly performed research as the sole responsibility of national, or federal, government (Sörlin, 2007). With regards to absolute amounts of financing for higher education, there has been a steady global increase in funding in the last decades. Behind these numbers, however, there is a disturbing inequality in distribution. As of today, more than 80 per cent of all resources spent on research and higher education are found in the 30 countries included in the Organisation for Economic Co-operation and Development (OECD). This pattern is, however, likely to change dramatically in the next decade, as many developing countries are currently experiencing a nearly exponential growth in student enrollments and in number of institutions of higher education. Following positive economic development, China and India, for example, have recently substantially increased their respective investments in higher education and research (Sörlin, 2006). With growing student enrollments and decreasing governmental support, many universities are unable to meet the educational needs of their societies. At the same time, research is increasingly concentrated in a lesser number of universities and private institutions, thereby creating an even more stratified educational system (Braddock, 2002). It is within this financial context that the issue of sustainability is emerging as an explicit policy objective and moral obligation for higher education (Wright, 2002); both challenges and opportunities for higher education to be a change agent are associated with these trends in higher education financing.

One challenge of increased private support of universities is that higher education becomes more reliant on and therefore potentially beholden to private interests. This could, in some circumstances, decrease the capacity for higher education to engage independently on important social issues like sustainability, especially in countries where the capacity for and engagement in quality research is limited. Another critical challenge with the increased privatization of research at universities is intellectual property rights. Complicated questions related to who owns the research generated at the university funded by a private entity emerge. However, an increased reliance on private funding can also be viewed as an opportunity. When private entities contribute to higher educational initiatives they generally want to be involved or kept up-to-date about what the institution is doing; this creates a direct mechanism for higher education to influence and impact private industry.

One useful example to illustrate both the challenges and opportunities in this private financing area can be seen in the USA where there have been several privately

supported climate change mitigation initiatives at universities. When the multinational oil company, BP, announced in February 2007 that it would be supporting a new Energy Biosciences Institute to focus on biofuels research, based at the University of California Berkeley, some stakeholders expressed concern that a public higher education institution would, by accepting this money from industry, no longer be independent and unbiased in its research and teaching.

To demonstrate the opportunities associated with this private funding it is useful to mention another BP-university partnership, a ten-year partnership based at Princeton University called the Carbon Mitigation Initiative funded by both BP and Ford, the automobile company. Within this partnership, which began in 2001, it is very clear that the companies involved in the partnership have been critically influenced by the academic researchers that they are supporting. Through regular communication as well as an annual meeting (attended by lead author Stephens) where the academics and the private sector representatives get together to reflect on progress of the initiative, the academics involved have unique opportunities to explain to their industry partners their long-term and theoretically grounded perspectives on the challenges of climate change science, technology, and policy. The interactions in this case have been synergistically valuable to both the university and industry representatives involved in the initiative, and have allowed the university to have global influence on private-sector climate change mitigation initiatives and energy technology innovation for climate change mitigation.

A different set of challenges and opportunities associated with financing of higher education is related to the more generic relative potential for private or public funds to support institutional reorganization of higher education that may promote enhanced university engagement in the transition toward sustainability. This issue is likely to vary considerably from place to place. In many countries with entrenched, traditional public education systems, structural change to allow for enhanced higher education involvement in social change toward sustainability may be unlikely without private investment. In some European countries, however, such as Sweden, there is already strong public support for changing the role, purpose and structure of institutions of higher education toward a sustainability focus.

An additional challenge with the apparent increased reliance in many places on private financing of higher education is that there may be some critical areas into which no private entity wants to invest, i.e. "the public goods" areas of sustainability (van Kerkhoff and Lebel, 2006). An example of this lack of interest in the private sector on specific critical problems can be seen in the problem of malaria: despite the sustained high number of malaria deaths, investment in managing malaria is lacking in comparison to investment in other problems.

A positive aspect of financing for universities moving toward sustainability is that there are opportunities for more money overall in the system if industry, businesses, and international cooperation channel money into higher education; this could allow for the expansion beyond the conventional roles of higher education. With corruption and inefficiencies in some publicly-funded educational systems, external support could have a strong benefit, increasing support of critical sustainability programs and allowing higher education to engage in new and different ways as a change agent in society. In some instances where corruption is widespread in the public system, universities may have more freedom and support to maintain their position as an

honest broker of information analysis and dissemination with more external financing; diversity of funding sources may allow for more independent thought and action. In some places this external funding could include international assistance for local sustainability programs within universities supported by a global net of universities and coordinated sustainability programs.

With regard to public financing of higher education, there are many educational systems that rely almost entirely on public funds (money raised through taxes). This may be an impediment for a changed mandate or structure for higher education. Changing a large, bureaucratic public education system can be very difficult, and such a change may sometimes require broader social awareness and acceptance of the sustainability challenges the community or region is facing and the potential role that the university could have in ameliorating those problems.

With some “external” seed money and good strategic programs, universities may be able to generate awareness of sustainability challenges in our societies by creating and demonstrating alternative visions of a better future and by promoting effective action to counteract problems and improve people’s quality of life. If this takes place and is recognized by society, the societal values and expectations of higher education will change. From a transition management theory perspective one would expect actors and institutions to both respond to change and act as agents in shaping change. Once higher education is seen as an institution with capacity to promote effective action from a neutral/independent position, the promotion of internal change within higher education to become more effective in shaping change towards sustainability is more likely.

2.3 What are the organization and structure of the higher education system?

The current organization and structure of higher education in different contexts should be evaluated to assess challenges and opportunities for an enhanced role as a change agent. One major challenge in this regard is that universities are inherently traditional and conventional, so changing the expectations of students, faculty members, or institutional priorities and institutional norms as far as societal engagement is a major challenge. Another critical structural challenge is the way that most institutions of higher education are divided into traditional disciplines. Disciplines and departments are often-times fiefdoms with specific internal cultures that prevent and dissuade cross-disciplinarity and limit engagement outside the conventional academic circle.

Another major challenge for higher education as a change agent is the structure for faculty promotion. In many higher education systems the current faculty promotion system fosters and rewards a narrow disciplinary focus and incentivizes the dissemination of research results primarily through publication in academic journals. The current academic system in most places does not reward public engagement, nor does it create time for academic researchers to reach out to non-academic stakeholders. The current dominant system explicitly dissuades trans-disciplinary collaborations and complex and integrated systems approaches to use-inspired research. While there are many specific examples of institutions of higher education that have recognized these challenges and attempted to change the current system (see below) the challenges associated with conventional academic reward mechanisms are major impediments to a more socially engaged higher educational system.

Despite these challenges, there are opportunities and positive emerging trends in university structure and organization. Several universities in recent years have re-structured their entire institutional design to incorporate enhanced social engagement toward a sustainability transition. One important example of this in the USA is Arizona State University (ASU), where a new school, the ASU School of Sustainability, was established in 2007 “to bring together multiple disciplines and leaders to create and share knowledge, train a new generation of scholars and practitioners, and develop practical solutions to some of the most pressing environmental, economic, and social challenges of sustainability, especially as they relate to urban areas”. Partnering with non-academic entities is a critical component of this new school, demonstrating recognition for the potential and opportunities for higher education to be a change agent. With these emerging programs, new opportunities exist for stakeholders outside of higher education to make connections and propose specific requests or partnerships with academics and higher education institutions.

Other examples of innovative institutional structures include Linköping University in Sweden, an institution that has used interdisciplinarity as its guiding principle for all of its activities in research and education since its founding in 1960. The university has developed several unique educational programs that transcend traditional academic borders and are defined by their societal relevance rather than by traditional disciplines, i.e. Management and Engineering, Technology and Social Change, and Water and Environmental Studies.

Another example from the USA of emerging alternative structures embedded within conventional academic institutions that integrate, support and encourage both interdisciplinarity and transdisciplinarity is Clark University’s Department of International Development, Community, and Environment. In this department, faculty with diverse disciplinary training (with PhDs in chemistry, anthropology, political science, engineering, geography, education, public policy, and urban and regional planning) are collaboratively building an educational program with an explicit scholar-practitioner focus and a commitment to facilitating positive social change. Also at Clark University, the Mosakowski Institute for Public Enterprise has been recently established, funded by a private donor, to foster and encourage faculty and students to engage in use-inspired research developed and conducted in conjunction with practitioners so that the results of the research have direct and immediate impacts on urgent societal needs. With regard to the challenges associated with conventional faculty promotion structures, Clark University has joined several other institutions in creating a new and alternative category of faculty positions called “Professors of Practice”; these positions legitimize the institutional, pedagogical, and social value of having faculty who are rewarded, promoted and recognized for active engagement and contributions outside of conventional academic venues, thus incentivizing more socially and practically engaged faculty.

Clearly opportunities and demand for these kinds of alternative socially engaged academic structures are growing worldwide. The King Abdullah University of Science and Technology (KAUST) in Saudi Arabia is an example of a new institution created with an agenda based on specific urgent societal problems that appears to explicitly commit to an interdisciplinary – perhaps even transdisciplinary – approach. Promotional materials explain that “A New Century Demands a New University...

A University Free of Barriers.” (KAUST, 2008). This institution is an international graduate-level research university with a mission of inspiring a new age of scientific achievement in the Kingdom that will also benefit the region and the world. Rather than schools or departments, the university has a structure of problem-specific research institutes to “discover solutions to the problems of our age-desertification, food and fresh water availability, fuel efficiencies, renewable energy and cleaner, more efficient chemical processes” (KAUST, 2008). The implementation of the social engagement of the university in the Saudi Arabian context is clearly associated with different challenges and opportunities than the US or European context.

One specific opportunity in considering higher education structure is associated with the established and declared socially engaged mission of universities in Latin America. Radical university reform promoted by students in 1918 in Argentina and later extended to all of Latin America, declares that all universities have a third social mission in addition to teaching and research called “extension.” Extension is defined as the direct interaction of the University with its environment in response to the demands of society. This extension mission has had limited financial or institutional support and has traditionally been operationalized as the unidirectional transfer of knowledge to less privileged classes. Despite the current limitations, this declared but unsubstantiated third mission of the university constitutes a distinct opportunity; a redefinition, re-envisioning, and implementation of the existing “extension” mission could enable and support two way interactions between the university and society in ways that allow universities to play a distinct role as a change agent toward a more sustainable society.

2.4 How strong are democratic processes?

Another critical question to ask in assessing challenges and opportunities for higher education as a change agent is related to the level and extent of democracy within the community or region where the institute of higher education is located. Within this general perspective, two specific components are worth considering:

- (1) accessibility and rights to obtain higher education; and
- (2) transparency and neutrality of higher education.

The accessibility of higher education is an important component in considering the potential for universities to facilitate social change. In places with low accessibility to higher education, universities may be viewed by some stakeholders as institutions whose primary influence is to empower the elite. With this view, the potential for higher education to have a positive and effective external influence or impact outside the campus borders may be reduced. For promoting a transition toward societal sustainability, broadening the scope and influence of accessibility of higher education could be a critical goal to broaden opportunities for higher education as an agent for social change.

An issue related to the accessibility of higher education is that of “rights”, i.e. to what extent the right to education is a normative component of citizenship. Clearly arguments can be made that the right to education is critical to a sustainable society. The relative perception and practicality of this perception in different cultures and contexts will limit the potential impact of higher education as a change agent.

Another component of the democratic perspective that may provide insights about opportunities for higher education as a change agent is that of transparency and neutrality. The fact that university research goes through the “peer-review” process institutionalizes a certain level of neutrality. The level of perceived and actual independence may vary in different cultures and contexts, and some degree of bias among academics and higher education is acknowledged in many places. There are, however, unique opportunities for higher education to be an “honest broker”, a potentially valuable role to play as an agent for change, particularly in mediating social discourse on complex and contentious societal tradeoffs that are necessary to consider in confronting some of the most challenging sustainability problems. This neutrality role for higher education could certainly be explored to a much larger extent than it is currently throughout the world. Building on this potential one specific way that universities can facilitate social change in this regard is by providing neutral arenas for debate, as well as providing neutral arenas for policy-making and activism.

One additional opportunity in this realm is the growth of higher education institutions that are explicitly devoted to the study and engagement of public policy. Harvard University’s John F. Kennedy School of Government is a prominent example of this, and there are many others throughout the world. The underlying mission and focus of these institutions embodies a direct influence on and engagement with politicians and other stakeholders in the development of policy approaches to improve society. These policy-focused institutions are increasing in numbers, and in addition the attention that these institutions are paying to policy challenges associated with sustainability is also growing. This is an area where higher education will likely accelerate its direct influence on policy analysis, development, and implementation.

2.5 What are the major channels for communication and interaction with society?

An additional area to consider in assessing both challenges and opportunities for higher education as a change agent is the cultural and institutional context associated with communication, information management, and interaction with society. This includes mechanisms for communication and dissemination of information both internally, within the higher education system, and externally with non-academic entities in society.

In considering communication and information dissemination internal to academia, there are challenges associated with limited cross-disciplinary and inter-departmental communication that could foster and enhance collaborations to address the integrated and complex challenges of sustainability. Although there is acknowledged need for multidisciplinary collaborations (Uiterkamp and Vlek, 2007), communication challenges can prevent or limit the effectiveness of such collaborations. These challenges are related to the structural and organizational challenges of higher education discussed in section 2.2. There are also obvious opportunities, however, for higher education to enhance internal communication and collaborations among experts in different areas to confront specific sustainability problems. These opportunities for enhanced communication exist within single institutions of higher education, and also among various different institutions. In the USA, for example, the Association for Advancement of Sustainability in Higher Education has been created to facilitate communication and information dissemination among a broad range of different types of higher education institutions with a mission of promoting sustainability in all

sectors of higher education including governance, operations, curriculum, and outreach. Higher education as a change agent

Existing mechanisms for communication and information dissemination outside of the higher education system are also very important to consider in specific contexts to understand the potential for higher education as a change agent. There are a variety of opportunities and potential mechanisms to enhance communication and engagement of university faculty, staff, and students with stakeholders external to the institution. There are wide discrepancies among the type and extent of access to decision-makers, policy-makers, industry, and community groups that representatives of higher education have in different places. For example, in Sweden, Germany and many other European countries there are specific mechanisms, such as institutionalized review and consulting processes, that require input from academics in the policy-making process. But these mechanisms are absent in many countries. In the United States, the National Academies brings together committees of experts in all areas of sciences and technology to address critical national issues and give advice to the federal government and the public. The National Academies is comprised of four distinct organizations: The National Academy of Sciences, the National Academy of Engineering, the Institute of Medicine, and the National Research Council. And in almost every context there is potential for increased outreach activities, more use-inspired research, and additional community engaged teaching that could be promoted and supported more explicitly by universities.

In the USA, communication between universities and industry is strong in some areas. Industry-university partnerships focused on climate change mitigation were mentioned in section 2.2, but there are many other examples. The Massachusetts Institute of Technology, for example, has always been an institution with close connections to industry, a place where the private sector often comes to get advice. There are clearly both challenges and opportunities in how higher education can enhance communication and engagement with the private sector to advance a sustainability transition.

One specific area where higher education has in many different cultures and contexts and served as a change agent in different ways is in the advancement of low-carbon emitting energy technologies. The US example of the Princeton Carbon Mitigation Initiative was mentioned in section 2.3. A very different context exists in India, where several institutions of higher education have been involved in the demonstration and adoption of solar cooking technology in rural communities. One example is the Avinashilingam Institute for Home Science and Higher Education for women, a university in the industrially developed community of Coimbatore, that has a program to demonstrate, encourage and educate the public on the practicality of using these solar cookers. This and other similar institutions of higher education have been functioning as networking agents in society to make connections between the manufacturers and the potential users who find a hard time choosing between different models available.

In Argentina and other Latin American countries where huge inequalities limit the access to knowledge and information to vast sectors of society, universities, through their declared “extension” mission, could be instrumental in facilitating access to interdisciplinary knowledge and honest analysis of information that is critical for the

adequate exercise of citizenship and the promotion of learning throughout society that is required to move toward more sustainable societies.

3. Historical context for considering higher education as a change agent

The notion that universities are important agents for social change is not novel. In fact throughout history academic institutions have played critical roles in broad societal changes. In considering current opportunities for higher education as an agent for change, understanding the factors that affect universities' ability to have an impact is critical. This is where the set of five categories of questions outlined in section 2 becomes a useful tool. When applied, these questions allow us to learn from the past as well as assess future challenges and opportunities for higher education as an agent for social change toward sustainability. To further illustrate the point, this section provides a brief discussion on higher education as a change agent throughout history.

The university is the "second oldest institution with a continuous history in the Western world after the Roman Catholic Church" (Rosenthal and Wittrock, 1993). While such longevity suggests stability, several major shifts in higher education have occurred. In the late 19th century, when research became an expected academic task the primary purpose of universities expanded from simply preserving and transmitting knowledge to also creating knowledge (Etzkowitz, 2001). Then during the Industrial Age, the role of universities further expanded to train technical professionals demanded by industrialization (Scholz *et al.*, 2003). During the past two decades, some researchers have postulated a second academic revolution. Some speculate that this would lead to a "triple helix" (Leydesdorff and Etzkowitz, 1996) with new intersections of industry, government and academia and a "third mission" of direct contributions to both industry and to society at large, "a change that would make participation in the progress of economic development into a core value" (Gibbons, 1999). While the "Triple Helix" perspective focuses on interactions among higher education, industry and government, with an emphasis on production, industry, and policy, an alternative perspective of transdisciplinarity focuses on interactions between higher education and a broad array of practitioners and stakeholders and the application of knowledge in society (Scholz *et al.*, 2006).

Universities, throughout history, have always held a critical place in society for advancing science. Given the current urgent societal challenges associated with environmental degradation and human health, the university role of advancing science in very practical and applicable ways is growing. The history of "the sciences" started with theology and philosophy (i.e. alpha sciences) which has been followed by the natural sciences (beta sciences) and the social sciences (gamma sciences). One question to ask now is what features characterize the kind of science now required to prepare society to confront the challenges of sustainability. These new sciences – which could be called delta sciences – should be able to cope with the solution or better "transformation" of complex, societally-relevant real problems that dominate environmental and sustainability issues (Leroy, 1999; Scholz *et al.*, 2000). This type of science would ask for knowledge integration and mutual learning among science, technology, administration, stakeholder groups, society at large etc. (Thompson Klein *et al.*, 2001; Thompson Klein, 2004).

The emerging new field of "sustainability science" may well embody a "delta science" (Kates *et al.*, 2001; Clark and Dickson, 2003a, b; Turner *et al.*, 2003; Clark,

2007). Sustainability science embraces use-inspired, interdisciplinary research that internalizes the link between knowledge and action, integrates social and physical sciences, and calls for the training of individuals to be able to deal with the complexity and interconnectedness associated with the major sustainability challenges facing society (Stokes, 1997; Kates *et al.*, 2001; Clark and Dickson, 2003a, b; van Kerkhoff and Lebel, 2006). The very creation of this concept of sustainability science demonstrates recognition within academia that there are major structural limitations in the conventional structure of higher education to advancing sustainability in society. How and to what extent universities will embrace and promote sustainability science is unclear, but there are several dramatic examples of major institutional restructuring of the university to support sustainability science including Arizona State University in the USA and the Lüneberg University in Germany (Beringer, 2007).

A critical question to consider at this point in history is whether the mastery of skills to confront the challenges of sustainability in the twenty-first century will be a focus similar to the mastery of technology of the industrial age in the twentieth century. At the end of the eighteenth century societal demands required technical skilled laborers for the industrial age, and the university system changed in response to that demand creating professional education, moving beyond the conventional university role of providing research competence and general knowledge. Now in response to societal challenges related to human-environment sustainability, new emerging requirements for professionals and researchers are evolving and there are new opportunities for universities to facilitate social change (Scholz *et al.*, 2003).

4. Conclusions

As the societal urgency associated with confronting the interconnected challenges of climate change, deforestation, species extinction, global inequality, and social injustice is rapidly increasing, the need for a transition toward more sustainable practices is becoming widely acknowledged in communities throughout the world. While the transition management literature provides some structure to consider the daunting scale and complexity of this transition, the potential for institutions of higher education has not been explicitly explored in this context. Clearly, institutions of higher education can be considered a stakeholder group with significant potential influence on society through many different mechanisms.

To consider the potential of higher education as a change agent in accelerating society's transition toward sustainability within a global context, the authors presented five critical questions to help assess challenges and opportunities in any particular region or place. Acknowledging that the challenges and opportunities are very context specific, the authors see value in recognizing, synthesizing and integrating common themes within which these challenges and opportunities can be assessed. Asking these five questions in specific contexts is likely to highlight issues that span the three levels of transition management: the strategic, the tactical, and the operational. The specific dominant sustainability challenges, the financing structure, the institutional organization, the extent of democratic processes, and the communication and information dissemination situation each have potential relevance to high-level strategic level concerns and decisions, to mid-level tactical decisions, and to more detailed operational-level planning.

This discussion encourages consideration of new mechanisms and approaches for teaching and conducting research in higher education that incorporates direct engagement with practitioners and stakeholders outside of academia. One particularly interesting and promising approach to foster the role of higher education as a change agent is the integration of transdisciplinary case studies. For the last 15 years, some European universities have effectively integrated case studies on regional, urban, and organizational sustainable transitions into research and the curriculum (Muhar *et al.*, 2006; Posch and Scholz, 2006; Posch and Steiner, 2006; Scholz *et al.*, 2006). In addition to the learning of the students and faculty, the practitioners who participate in these case studies are also learning (Walter and Helgenberger, 2007). In some instances a university professor and a practitioner take on co-leadership of the case study, including co-authorship of the publication or the implementation of the results (Scholz and Stauffacher, 2007). This approach could be supported and expanded in institutions of higher education throughout the world in many different contexts to create a specific and replicable mechanism for the university as a change agent.

The examples described throughout this discussion to demonstrate the contextual variation in challenges and opportunities illustrate a spanning of the three levels of transition management. Given the heterogeneity of the roles, interests, and expertise of individuals associated with institutions of higher education (including faculty, students, staff, administration, and alumni), generalizations related to the capacity of the institution to be a change agent run the risk of oversimplifying very complex situations. The authors hope that this paper's integrated consideration of the institutional potential of higher education as a change agent is helpful in highlighting potential mechanisms to enhance societal capacity to persist and endure the scale of environmental, social, and technical change currently being experienced.

References

- Barlett, P.F. and Chase, G.W. (Eds) (2004), *Sustainability on Campus, Stories and Strategies for Change*, MIT Press, Cambridge, MA.
- Beringer, A. (2007), "The Luneburg Sustainable University Project in international comparison: an assessment against North American peers", *International Journal of Sustainability in Higher Education*, Vol. 8 No. 4, pp. 446-61.
- Braddock, R. (2002), "Research management in higher education: overview and conclusion of a debate", *Higher Education Policy*, Vol. 15, pp. 313-30.
- Clark, W.C. (2007), "Sustainability science: a room of its own", *Proceedings of the National Academy of Sciences of the United States of America*, Vol. 104 No. 6, pp. 1737-8.
- Clark, W.C. and Dickson, N.M. (2003a), "Science and technology for sustainable development special feature: sustainability science: the emerging research program", *PNAS*, Vol. 100 No. 14, pp. 8059-61.
- Clark, W.C. and Dickson, N.M. (2003b), "Sustainability science: the emerging research program", *Proceedings of the National Academy of Sciences of the United States of America*, Vol. 100 No. 14, pp. 8059-61.
- Colucci-Gray, L., Camino, E., Barbiero, G. and Gray, D. (2006), "From scientific literacy to sustainability literacy: an ecological framework for education", *Science Education*, Vol. 90 No. 2, pp. 227-52.
- Creighton, S.H. (1998), *Greening the Ivory Tower: Improving the Environmental Track Record of Universities, Colleges and Other Institutions*, MIT Press, Cambridge, MA.

- Etzkowitz, H. (2001), "The second academic revolution and the rise of entrepreneurial science", *IEEE Technology and Society Magazine*, Vol. 20 No. 2, pp. 18-29.
- Ferrer-Balas, D. and Buckland, H. *et al.* (2007), "Explorations on the University's role in society for Sustainable development through a systems transition approach", case-study of the Technical University of Catalonia (UPC).
- Ferrer-Balas, D., Adachi, J., Banas, S., Davidson, C.I., Hoshikoshi, A., Mishra, A., Motodoa, Y., Onga, M. and Ostwald, M. (2008), "An international comparative analysis of sustainability transformation across seven universities", *International Journal of Sustainability in Higher Education*, Vol. 9 No. 3, pp. 295-316.
- Filho, W.L. (2000), "Sustainability and university life", *International Journal of Sustainability in Higher Education*, Vol. 1 No. 2, pp. 168-81.
- Gibbons, M. (1999), "Science's new social contract with society", *Nature*, Vol. 402 No. 6761, pp. C81-4.
- Kates, R.W. (1995), "Presidential address: labnotes from the Jeremiah experiment: hope for a sustainable transition", *Annals of the Association of American Geographers*, Vol. 85 No. 4, pp. 623-40.
- Kates, R.W., Clark, W.C., Corell, R., Hall, J.M., Jaeger, C.C., Lowe, I., McCarthy, J.J., Schellnhuber, H.J., Bolin, B., Dickson, N.M., Faucheux, S., Gallopin, G.C., Grubler, A., Huntley, B., Jäger, J., Jodha, N.S., Kasperson, R.E., Mabogunje, A., Matson, P., Mooney, H., Moore, B. III, O'Riordan, T. and Svedin, U. (2001), "Environment and development – sustainability science", *Science*, Vol. 292 No. 5517, pp. 641-2.
- Kemp, R. and Loorbach, D. (2003), "Governance for sustainability through transition management", paper presented at Open Meeting of Human Dimensions of Global Environmental Change Research Community, Montreal, Canada.
- Kemp, R., Loorbach, D. and Rotmans, J. (2007), "Transition management as a model for managing processes of co-evolution towards sustainable development", *The International Journal of Sustainable Development and World Ecology*, Vol. 14 No. 1, pp. 78-91.
- Kemp, R., Schot, J. and Hoogma, R. (1998), "Regime shifts to sustainability through processes of niche formation: the approach of strategic niche management", *Technology Analysis and Strategic Management*, Vol. 10 No. 2, pp. 175-95.
- King Abdullah University of Science and Technology (KAUST) (2008), available at: www.kaust.edu.sa/about/21st-century.aspx (accessed 24 March 2008).
- Klein, J.T. and Newell, W.H. (1997), "Advancing interdisciplinary studies", *Handbook of Undergraduate Curriculum*, Jossey-Bass, San Francisco, CA.
- Laws, D., Scholz, R.W., Shiroyama, H., Susskind, L., Suzuki, T. and Weber, O. (2004), "Expert views on sustainability and technology implementation", *International Journal of Sustainable Development and World Ecology*, Vol. 11 No. 3, pp. 247-61.
- Leroy, P. (1999), *Social and Political Sciences of the Environment. Three Decades of Research in The Netherlands*, International Books, Utrecht.
- Leydesdorff, L. and Etzkowitz, H. (1996), "Emergence of a triple helix of university-industry-government relations", *Science and Public Policy*, Vol. 23, pp. 279-86.
- Liu, J., Dietz, T., Carpenter, S.R., Alberti, M., Folke, C., Moran, E., Pell, A.N., Deadman, P., Kratz, T., Lubchenco, J., Ostrom, E., Ouyang, Z., Provencher, W., Redman, C.L., Schneider, S.H. and Taylor, W.W. (2007), "Complexity of coupled human and natural systems", *Science*, Vol. 317 No. 5844, pp. 1513-16.

- Loorbach, D. and Kemp, R. (2005), "Innovation policy for the Dutch energy transition: the multilevel governance aspects", paper presented at 45th Congress of the European Regional Science Association, Amsterdam.
- Maclea, R. and Ordonez, V. (2007), "Work, skills development for employability and education for sustainable development", *Educational Research for Policy and Practice*, Vol. 6, pp. 123-40.
- Marshall, J.D. and Toffel, M.W. (2005), "Framing the elusive concept of sustainability: a sustainability hierarchy", *Environmental Science & Technology*, Vol. 39 No. 3.
- Martens, P. (2006), "Sustainability: science or fiction?", *Sustainability: Science, Practice, and Policy*, Vol. 2 No. 1.
- Mendivil, J.L.I. (2002), "The new providers of education", *Higher Education Policy*, Vol. 15, pp. 353-64.
- Muhar, A., Vilsmaier, U., Glanzer, M. and Freyer, B. (2006), "Initiating transdisciplinarity in academic case study teaching: experiences from a regional development project in Salzburg, Austria", *International Journal of Sustainability in Higher Education*, Vol. 7 No. 3, pp. 293-308.
- Mulder, K.F. (2004), "Engineering education in sustainable development: sustainability as a tool to open up the windows of engineering institutions", *Business Strategy and the Environment*, Vol. 13, pp. 275-85.
- Posch, A. and Scholz, R.W. (2006), "Transdisciplinary case studies for sustainability learning", *International Journal of Sustainability in Higher Education*, Guest Editorial, Vol. 7 No. 3, pp. 221-5.
- Posch, A. and Steiner, G. (2006), "Integrating research and teaching on innovation for sustainable development", *International Journal of Sustainability in Higher Education*, Vol. 7 No. 3.
- Power, C. (2006), "Education for the future: an international perspective", *Educational Research for Policy and Practice*, Vol. 5, pp. 165-74.
- Rappaport, A. (2008), "Campus greening, behind the headlines", *Environment, Science and Policy for Sustainable Development*, Vol. 50 No. 1, pp. 6-16.
- Rappaport, A. and Creighton, S.H. (2007), *Degrees that Matter*, MIT Press, Cambridge, MA.
- Ravetz, J.R. (2006), "Post-normal science and the complexity of transitions towards sustainability", *Ecological Complexity*, Vol. 3 No. 4, pp. 275-84.
- Rosenthal, R. and Wittrock, B. (1993), *The European and American Universities since 1800: Historical and Sociological Essays*, Cambridge University Press, Cambridge.
- Rotmans, J., Kemp, R. and van Asselt, M. (2001), "More evolution than revolution: transition management in public policy", *foresight – the journal of future studies, strategic thinking, and policy*, Vol. 3 No. 1, pp. 15-31.
- Scholz, R.W. and Stauffacher, M. (2007), "Managing transition in clusters: area development negotiations as a tool for sustaining traditional industries in a Swiss pre-alpine region", *Environment and Planning A*, No. 39, pp. 2518-39.
- Scholz, R.W., Mieg, H.A. and Oswald, J.E. (2000), "Transdisciplinarity in groundwater management: towards mutual learning of science and society", *Water Air and Soil Pollution*, Vol. 123, pp. 477-87.
- Scholz, R.W., Steiner, R. and Hansmann, R. (2003), "Role of internship in higher education in environmental sciences", *Journal of Research in Science Teaching*, Vol. 41 No. 1, pp. 24-46.
- Scholz, R.W., Lang, D.J., Wiek, A., Walter, A.I. and Stauffacher, M. (2006), "Transdisciplinary case studies as a means of sustainability learning, historical framework and theory", *International Journal of Sustainability in Higher Education*, Vol. 7 No. 3, pp. 226-51.

- Sörlin, S. (2006), "Introduction: the democratic deficit of knowledge economies", in Sörlin, S. and Vessuri, H. (Eds), *Knowledge Society vs Knowledge Economy: Knowledge, Power, and Politics*, Palgrave Macmillan, New York, NY, pp. ix-xxxvi.
- Sörlin, S. (2007), "Funding diversity: performance-based funding regimes as drivers of differentiation in higher education systems", *Higher Education Policy*, Vol. 20 No. 4, pp. 413-40.
- Steffen, W., Crutzen, P.J. and McNeill, J.R. (2007), "The anthropocene: are humans now overwhelming the great forces of nature?", *Ambio: A Journal of the Human Environment*, Vol. 36 No. 8, pp. 614-21.
- Stokes, D.E. (1997), *Pasteur's Quadrant: Basic Science and Technological Innovation*, Brookings Institution, Washington, DC.
- Svanström, M., Lozano-García, F.J. and Rowe, D. (2008), "Learning outcomes for sustainable development in higher education", *International Journal of Sustainability in Higher Education*, Vol. 9 No. 3, pp. 339-51.
- Thaman, K.H. (2002), "Shifting sights: the cultural challenge of sustainability", *Higher Education Policy*, No. 15, pp. 133-42.
- Thompson Klein, J. (2004), "Prospects for transdisciplinarity", *Futures*, Vol. 36, pp. 515-26.
- Thompson Klein, J., Grossenbacher-Mansuy, W., Häberli, R., Bill, A., Scholz, R.W. and Welti, M. (2001), *Transdisciplinarity: Joint Problem Solving among Science, Technology, and Society. An Effective Way for Managing Complexity*, Birkhauser, Basel.
- Turner, B.L. II, Kasperson, R.E., Matson, P.A., McCarthy, J.J., Corell, R.W., Christensen, L., Eckley, N., Kasperson, J.X., Luers, A., Martello, M.L., Polsky, C., Pulsipher, A., Schiller, A., Selin, H. and Tyler, N. (2003), "Science and technology for sustainable development special feature: a framework for vulnerability analysis in sustainability science", *Proceedings of the National Academy of Sciences*, Vol. 100 No. 14, pp. 8074-9.
- Uiterkamp, A. and Vlek, C. (2007), "Practice and outcomes of multidisciplinary research for environmental sustainability", *Journal of Social Issues*, Vol. 63 No. 1, pp. 175-97.
- van Kerkhoff, L. and Lebel, L. (2006), "Linking knowledge and action for sustainable development", *Annual Review of Environment and Resources*, Vol. 31, pp. 445-77.
- Wals, A.E.J. and Jickling, B. (2002), "Sustainability in higher education: from doublethink and newspeak to critical thinking and meaningful learning", *Higher Education Policy*, Vol. 15, pp. 121-31.
- Walter, A.I. and Helgenberger, S. (2007), "Measuring societal effects of transdisciplinary research projects: design and application of an evaluation method", *Evaluation and Program Planning*, Vol. 30, pp. 325-38.
- Wright, T.S.A. (2002), "Definitions and frameworks for environmental sustainability in higher education", *Higher Education Policy*, Vol. 15, pp. 105-20.

About the authors

Jennie C. Stephens is an Assistant Professor of Environmental Science and Policy in the Department of International Development, Community, and Environment at Clark University and an associate of the Energy Technology Innovation Policy group at Harvard University's Kennedy School. Stephens' research focuses primarily on socio-political aspects of the advancement of energy technologies for climate change mitigation. A recent focus of this work has been on the social drivers for and social implications of carbon capture and storage technology. She is the corresponding author and can be contacted at: jstephens@clarku.edu

Maria E. Hernandez is a junior faculty member at Universidad Tecnológica Nacional, UTN - Facultad Regional Tucumán (FRT), where she is part of an Environmental Engineering Center

and developing a new Environmental Engineering Master Program. She has served as a University representative to the Environmental Council of Economy and Environment in the provincial government. She received her PhD from the California Institute of Technology in 2004 in Environmental Science and Engineering and, on finishing she returned to her native city in Argentina where she has been involved in academic, NGO and government work related to sustainability and environmental education.

Mikael Román is Senior Researcher at Stockholm Environment, with a PhD in political science from Department of Government at Uppsala University, Sweden, specializing in the areas of: policy evaluation; international relations; science, technology and public policy; environmental regulation; and corporate strategies.

Amanda C. Graham is Director of the Education Office at the Massachusetts Institute of Technology's Energy Initiative. In this role she coordinates faculty, students and staff in the development, implementation, monitoring and evaluation of energy, environmental and sustainability education programs for MIT undergraduate and graduate students. Emerging energy curriculum development activities at MIT include a new cross-disciplinary undergraduate minor, an "energy teaching scholars" program to train outstanding new faculty. In 2007 Graham convened nearly 50 educators from four continents for the "Going Global" international working sessions on sustainability in higher education. She collaborates with international partners in the Alliance for Global Sustainability, including "Teaching Energy and Climate" and the University of Tokyo's "Intensive Program on Sustainability" Graham's pedagogical approach emphasizes multi-disciplinary, project-based, experiential education. She received her BA in Social and Environmental Policy from Williams College, and her MS in Forestry-Social Sciences and PhD in communication from the University of Washington.

Roland W. Scholz holds the Chair of Environmental Sciences: Natural and Social Science Interface at the Swiss Federal Institute of Technology (ETH Zurich, Switzerland). He is adjunct professor of Psychology at the University of Zurich (Privatdozent), and was elected as the fifth holder of the King Carl XVI Gustaf's Professorship 2001/2002 hosted at the Center of Environment and Sustainability of Chalmers University of Technology and Gothenborg University (Sweden). Since 2002, he is the speaker of the International Transdisciplinarity Network on Case Study Teaching (ITdNet).