J Soc Sci, 49(3): 183-194 (2016)
PRINT: ISSN 0971-8923 ONLINE: ISSN 2456-6756
DOI: 10.31901/24566756.2016/49.3-i.01

Using Adaptive Governance to Enhance Transitions toward Sustainable and Resilient Energy Systems

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KEYWORDS Africa. Biofuels. Renewable. Resilience. Vulnerability. Well-being

ABSTRACT The field of energy policy is concerned with the promotion of energy production systems and consumption patterns that enhance socio-economic well-being, energy efficiency, environmental protection, and equitable access. It is increasingly recognized that the attainment of sustainable energy systems requires a transformation from the current system, characterized by the dominance of fossil fuels, toward an alternative system that accommodates renewable energy sources, such as wind, solar, modern biomass, and small-scale hydropower. Renewable energy sources offer several advantages, including environmental friendliness, diversity, security, and opportunities for local community involvement through decentralized management. Yet the process of transition toward alternative energy supply sources has been slow. Using theoretical insights from research on resilience in social-ecological systems, this paper argues for an adaptive governance approach to enhancing the transition toward sustainable and resilient energy systems in sub-Saharan Africa in the face of the uncertainties and conflicts that characterize the energy transition process.

INTRODUCTION

The concept of sustainable development which was popularized in the World Commission on Environment and Development (WCED) report in 1987 refers to "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (p. 43). Key components of sustainable development include economic efficiency, social equity, and environmental conservation. The sustainable development concept also calls for institutional arrangements that promote democracy and participatory decision-making, particularly at the local level (Wheeler 2010; Stirling 2014). The sustainable development concept has received several criticisms for its ambiguity, anthropocentric orientation, endorsement of the nature-culture dichotomy, emphasis on Western cultural values, inadequate interrogation of Western consumption standards, and endorsement of technological fixes to current ecological problems (Giddings et al. 2002; Wheeler 2010). Notwithstanding these criticisms, sustainable development continues to be one of the most widely discussed concepts and guiding principles among scientists and policymakers in the field of development and the environment.

There is increasing recognition that the energy sector is of critical importance and needs to play a central role in strategies aimed at achieving sustainable development (Jaccard et al. 2012). As Giner-Reichl (2015: 116) has succinctly stated, "It is hardly conceivable to discuss "sustainable development" without also examining the production, distribution and use of energy." The growing recognition of the importance of the energy sector in sustainable development is evident in recent global initiatives, such as the United Nations Secretary-General's Sustainable Energy for All initiative, which was launched in 2011 to enhance universal energy access, improve energy efficiency, and promote the use of renewable energy. To enhance the contributions of the energy sector to sustainable development, energy policies need to respond to the social, economic and ecological dimensions of the sustainable development concept (Jaccard et al. 2012).

The world's energy system continues to be locked-in to the use of fossil fuels (coal, gas, and oil) and this presents significant policy challenges for the contributions of the energy sector to sustainable development (Hodbod and Adger 2014). The Global Energy Assessment (GEA) report notes that the world's energy demand is growing at a rate of about two percent per year, with fossil fuels contributing about eighty percent of the energy supply (GEA 2012). Based on current production and consumption patterns, Goldemberg (2007) estimates that fossil fuels cannot be relied upon as the primary source of fuel for more than the next one or two generations. Besides the limits to supply, fossil fuels are also known to emit carbon dioxide and other greenhouse gases that contribute to global warming with attendant climate change consequences including floods and drought (Omer 2008). Moreover, there are concerns over the lack of energy security, as much of the world's oil supply comes from politically volatile regions (Goldemberg 2007). Importantly, there is the lack of universal access to modern energy services, which is critical to enhancing overall living standards (GEA 2012; Hodbod and Adger 2014). The World Energy Outlook (WEO) report estimates that two out of every three people in sub-Saharan Africa lack access to electricity (WEO 2014). Bioenergy, mostly wood and charcoal, accounts for sixty percent of energy demand on the continent (Hancock 2015b). Globally, three billion people have no access to basic energy services and rely on solid fuels for cooking and heating (GEA 2012). The high dependence on traditional biomass in sub-Saharan Africa and other developing regions is thought to be inefficient, environmentally destructive, and has adverse health and socio-economic consequences (Goldemberg 2007; GNESD 2011; Hancock 2015b).

The pursuit of sustainable energy systems with the potential to address the social, economic and ecological concerns of sustainable development calls for a transition toward greater utilization of renewable energy sources (Goldemberg 2007; Engelken et al. 2016; Lugaric and Krajcar 2016). Renewable sources of energy, such as small-scale hydropower, wind power, solar energy, geothermal energy and modern biomass are beginning to receive attention as alternatives to fossil fuels. These alternatives have the potential to reduce energy poverty among the rural poor, enhance energy security by diversifying the supply sources, reduce adverse environmental and climate impacts, and contribute to socio-economic development at the local and national levels (Goldemberg 2007; Lee et al. 2008; Haselip et al. 2011; Fulquet and Pelfini 2015). Renewable sources of energy are also more amenable to decentralized management, which creates opportunities for stakeholder involvement (O'Brien and Hope 2010). Out of the renewable sources of energy, bioenergy provides the most promise as a viable alternative to fossil fuels (Lee et al. 2008; GNESD 2011). A report by the World Energy Council (WEC 2010) predicts that bioenergy could potentially contribute between a quarter and a third of the global energy mix in the future, up from its current contribution of about ten percent of global energy consumption.

A number of notable examples exist on the transition toward renewable energy sources, such as the cases of Denmark (Lund 2007), Brazil (Goldemberg 2007) and Germany (Engelken et al. 2016). In sub-Saharan Africa, progress in the transition toward renewable energy is evident in the adoption of national policies prioritizing the development of renewable energy in various countries, such as Ghana, Senegal, Tanzania and Zambia (Haselip et al. 2015), as well as the emergence of various regional organizations promoting renewable energy, such as the ECOWAS Centre for Renewable Energy and Energy Efficiency (Giner-Reichl 2015; Hancock 2015a). Notwithstanding these optimistic developments, there is general consensus that the transition toward renewable energy sources has been slow, particularly in the case of sub-Saharan Africa where the abundant renewable energy sources remain largely underdeveloped (Mukasa et al. 2015) and understudied (Hancock 2015b).

Studies on the adoption of renewable energy technologies in sub-Saharan Africa reveal a range of sociocultural, economic, institutional, technological, infrastructure and ecological factors across multiple scales that constrain the transition toward renewable energy sources (Haselip et al. 2011; Haselip et al. 2015; Mukasa et al. 2015). From the perspective of diffusion of innovations (Fliegel and Korsching 2001; Rogers 2003), four key policy challenges can be discerned from the interaction among the various constraints to the adoption of renewable energy technologies in sub-Saharan Africa and beyond. The first impediment to the widespread adoption of renewable energy sources is the absence of reliable, efficient and sustainable renewable energy technologies. Shortfalls have been identified in existing technologies, such as wind turbines (Mukasa et al. 2015), solar installations (Haselip et al. 2015), and first-generation biofuel technologies that relied on food-derived sources as feedstock (GNESD 2011). The second challenge relates to the lack of communication among stakeholders, and the lack of reliable information to inform the complex decisions on energy systems and to counter the general lack of awareness on the benefits and opportunities for investment in renewable energy sources (Haselip et al. 2015). Third, there is the absence of appropriate incentive mechanisms for generating interest in the development and utilization of renewable sources of energy (Mukasa et al. 2015). Finally, limitations in capacity requirements, such as human, economic and physical capital, constitute a major challenge to the adoption of renewable energy sources in sub-Saharan Africa (Fulquet and Pelfini 2015; Haselip et al. 2015). In view of these lessons, there is growing realization that the transition toward renewable energy sources in sub-Saharan Africa and elsewhere will require innovative institutional mechanisms and policy frameworks that provide an enabling environment for the development of renewable energy technologies, as well as providing the information, incentives and resources for the widespread adoption of such technologies (Lee et al. 2008; Jaccard et al. 2012; Fulquet and Pelfini 2015).

Using theoretical insights from the literature on social-ecological resilience and the adaptive governance of social-ecological systems, this paper analyzes key policy considerations in creating such an enabling policy environment for enhancing the transition toward sustainable and resilient renewable energy systems. Following Hodbod and Adger's (2014) conceptualization of energy systems as complex social-ecological systems, the article argues for an adaptive governance approach to overcoming the challenges in the transition toward renewable energy systems, as well as building the resilience and robustness of energy systems in the face of the value conflicts and knowledge uncertainties in the transition process. The subsequent sections of the article are organized into four main parts. First, theoretical perspectives in social-ecological systems research and adaptive governance will be presented. Next, methodological procedures for selecting and analyzing relevant publications will be described. In the following section, Key policy considerations for enhancing the adoption of renewable energy sources will be presented and discussed from the adaptive governance perspective. These considerations include the need for an integrated management approach that is holistic and multi-sectoral in scope, the need for multiple sources of knowledge, the use of flexible multi-level institutions, and emphasis on conflict management. The last section of the paper contains reflections and concluding comments on the transition toward renewable energy sources in sub-Saharan Africa.

Theoretical Framework

Resilience and Robustness in Social-ecological Systems

Failures from the conventional command and control approach to development and the environment have revealed that such policies were underpinned by two flawed assumptions. First, social and ecological systems were treated as distinct from each other. Second, natural ecosystem responses to human interventions were assumed to be easily predicted and controlled (Folke et al. 2002). Over the last two decades, an alternative perspective has emerged that looks at social and ecological systems coupled as social-ecological systems (Redman et al. 2004). The concept of social-ecological systems is applicable to the energy sector, forests and water resources, as well as all resource systems in which social systems and ecological systems interact with each other in a dynamic and co-evolutionary fashion across multiple spatial and temporal scales (Anderies et al. 2004; Ostrom 2009). Such coupled social-ecological systems exhibit the attributes of complex adaptive systems, such as cross-scale interactions, path-dependency, heterogeneity, emergence, and surprise (Folke 2007; Liu et al. 2007). Holling's (2001) panarchy theory depicts social-ecological systems as a hierarchy of inter-dependent adaptive cycles. The adaptive cycle is a model that illustrates the four-phase cycle of change in social-ecological systems of growth, accumulation, restructuring, and renewal (Holling 2001). The cross-level interactions among smaller and faster adaptive cycles at lower levels, and larger and slower adaptive cycles at higher levels accounts for the resilience of the entire system (Cosens et al. 2014). The sustainable governance of such complex social-ecological systems requires enhancing their resilience.

Holling's (1973) concept of resilience was intended to serve as a more appropriate descriptor of ecosystem behaviors as opposed to the concept of "static stability" that was used in the old paradigm (Wu and Loucks 1995). There are roughly four types of resilience indicated in the literature. First, ecological resilience is defined as the capacity of a system to absorb disturbance and reorganize while still maintaining its structure and function (Walker et al. 2004; Cosens et al. 2014). Second, social resilience refers to the ability of groups or communities to cope with external stresses and disturbances as a result of social, political and environmental change (Adger 2000). Third, engineering resilience may be defined as return time after disturbance or the time it takes for a system to return to a predisturbance equilibrium (Gunderson and Light 2006). According to Folke (2006), engineering resilience is about resisting disturbance and change so as to maintain efficiency of function, constancy of the system, and a predictable world near a single steady state. Closely related to engineering resilience is the concept of robustness. The robustness concept also has its roots in engineering where it refers to "the capacity of a system to maintain its performance when subjected to internal and external perturbations" (Janssen and Anderies 2007: 46). The robustness concept has been argued to be a more appropriate concept for the study of institutions because they are human designed elements of the social-ecological system, just as engineering systems are human designed (Anderies et al. 2004, Janssen and Anderies 2007). Arguably, robustness may be a more useful form of resilience in the analysis of energy systems, especially where the focus is on the human-designed infrastructure. Fourth, Folke (2006) further introduces the concept of social-ecological resilience which incorporates three different interpretations of the amount of disturbance a system can absorb and still remain within the same state or domain of attraction, the degree to which the system is capable of self-organization, and the degree to which the system can build and increase the capacity to learn and adapt. In this paper, resilience is used to imply social-ecological resilience since it is the most amenable to the analysis of evolving human-environment interactions in renewable energy sources as complex social-ecological systems.

Adaptive Governance of Social-ecological Systems

From this discussion, it is evident that building resilience and reducing vulnerability of social-ecological systems is critical to their sustainability. The design of effective institutions, the humanly devised formal and informal constraints that structure social interactions (North 1990), is very essential in building social-ecological resilience. The resilience concept has also become the theoretical foundation for emerging natural resource management concepts, such as adaptive management (Walters 1997), and adaptive governance (Folke et al. 2005; Akamani 2016).

Adaptive management is one of the earliest resource management approaches that emerged from resilience thinking (Gunderson and Light 2006). This resource management approach recognizes the inherent uncertainties and unpredictability in the resource management process. Allen et al. (2011) describe adaptive management as "an approach to natural resource management that emphasizes learning through management based on the philosophy that knowledge is incomplete and much of what we know is actually wrong, but despite uncertainty managers and policymakers must act" (p. 1339). Adaptive management attempts to deal with the incomplete knowledge and uncertainties by treating resource policies as hypotheses, and policy implementation as experiments to test alternative policy options (Raadgever et al. 2008). Adaptive management relies on an iterative process that facilitates learning, as well as the subsequent integration of new knowledge into the resource management process (Lee 1999). Through this ongoing learning and adaptation process, adaptive management holds promise for building resilience and reducing vulnerability to uncertainty and surprise (Allen et al. 2011). However, success in adaptive management requires a favorable social and institutional context (Gunderson and Light 2006). Adaptive management requires adaptive governance in order to be successful (Walker 2012).

Adaptive governance is an institutional mechanism that focuses on the broader social and institutional context within which ecosystem-based resource management occurs (Folke et al. 2005; Gunderson and Light 2006; Karpouzoglou et al. 2016). Given its orientation toward ecosystem management approaches, the goals of adaptive governance are necessarily holistic, covering not only the social, economic or ecological aspect but an integration of all dimensions of sustainability at multiple scales (Gunderson and Light 2006; Folke et al. 2011). Adaptive governance regimes also tend to draw from multiple types of knowledge, as opposed to the over-reliance on reductionist science in conventional resource management (Nelson et al. 2008; West and Schultz 2015). Adaptive governance connects different types of actors across multiple scales in an ongoing process of learning and adaptation to uncertainty and change (Olsson et al. 2006).

Dietz et al. (2003) identified three key attributes of the institutional structures and processes entailed in adaptive governance. First, adaptive governance relies on analytic deliberation processes, which refer to decision-making processes in which decision-makers, scientists and other stakeholders interact in an ongoing process that allows for the combination of scientific analysis and stakeholder deliberation in managing value conflicts and knowledge uncertainties (Akamani and Wilson 2011). Through this process, adaptive governance provides an effective mechanism for linking science and policy in planning processes (Gunderson and Light 2006). A second defining attribute of adaptive governance is nested institutions. The need for nested institutions arises from the awareness that no single level of intervention will be adequate in addressing the multiple scales of interaction in complex social-ecological systems (Akamani and Wilson 2011; Akamani 2016). Nested institutions are therefore essential in enhancing the fit between policy interventions and the levels at which problems occur in the social-ecological system (Olsson and Galaz 2009). Finally, adaptive governance institutions are diverse, composed of states, markets and communities. The diversity issue is critical for enhancing the institutional performance and resilience of the system since no single type of institution can effectively deal with all problems and surprises at all times (Dietz et al. 2003; Akamani and Wilson 2011). Given all these attributes, adaptive governance institutions are widely discussed as promising mechanisms for promoting good governance, managing conflicts, and building capacities for adaptation and transformation (Olsson et al. 2007; Akamani and Wilson 2011; Walker 2012). Based on these insights from the literature, this chapter argues that an adaptive governance approach could provide an effective guide for formulating policies aimed at enhancing the transition toward sustainable and resilient energy systems that rely mostly on renewable energy sources.

METHODOLOGY

Following procedures applied in recent review manuscripts (for example Koontz et al. 2015), data for this paper were generated through a systematic review of the relevant literature. Using key words, such as “adaptive governance,” “energy transitions,” and “renewable energy,” the researcher critically reviewed publications that primarily contains theoretical or empirical information on transitions in social-ecological systems in general or transitions in energy systems towards renewable energy sources in particular. The selected publications included those on the West African sub-region, as well as other geographic regions. We analyzed the publications to identify the factors influencing transitions in energy systems and the role that institutional mechanisms for adaptive governance of social-ecological systems could play in promoting successful transitions toward renewable energy sources. Following Karpouzoglou et al. (2016), we conducted a final search of the literature to include references that were either not yet available or not identified at the initial stages of the study.

OBSERVATIONS AND DISCUSSION

This section draws from the literature review to discuss the potential applications of conceptual insights on resilience and adaptive governance of social-ecological systems to the formulation of enabling policies for enhancing the transition toward renewable energy sources in sub-Saharan Africa.

Recognizing Energy Systems as Social-ecological Systems

Energy systems are complex social-ecological systems that exhibit attributes, such as scale, path dependence, as well as surprise and uncertainties (Araujo 2014; Hodbod and Adger 2014). Policies promoting renewable energy sources will need to be underpinned by an awareness of this complexity in order to enhance resilience and reduce vulnerability in energy systems (O’Brien and Hope 2010). Regarding the issue of scale, energy systems are subject to influences across multiple scales, ranging from the local to the global, including socio-cultural, economic, technological, political, and ecological forces (O'Brien and Hope 2010; Goldthau 2014; Hodbod and Adger 2014). Energy systems and policies are themselves organized along multiple scales. For instance, energy infrastructure may be interconnected at the local, provincial, national and even regional levels. Policy interventions targeting each level of the energy system have implications for other levels below and above the chosen level of intervention (Goldthau 2014). The trade-offs associated with the cross-scale dynamics in energy systems deserve greater understanding in order to minimize unintended consequences (Hodbod and Adger 2014). Recent years have seen a growing interest in regional approaches to energy planning and infrastructure development in sub-Saharan Africa (Giner-Reichl 2015; Hancock 2015a; Saadi et al. 2015). The cross-scale implications of these regional level initiatives deserve careful analysis in order to minimize unintended outcomes.

Given the complex interactions among the multiple components of energy systems and other sectors, surprise is inevitable in the process and outcomes of energy policies. For instance, the implementation of renewable energy policies based on first-generation bioenergy technologies that relied on food crops as feedstock has been associated with unintended outcomes, such as rising food prices, land grabs, land degradation, threats to livelihood security, and socio-political instability (Lee et al. 2008; Hodbod and Adger 2014; Hancock 2015b). Analysis of biofuels projects in Ghana (Tsikata and Yaro 2011), and sub-Saharan Africa as a whole (Fulquet and Pelfini 2015) illustrate the adverse impacts of these large-scale, externally owned biofuels projects on rural communities, including threats to customary tenure, common pool resources, local livelihood sustainability, and community autonomy. The adverse impacts of biofuels projects have partly been blamed on failure to integrate policies on biofuels production into those on related sectors (Lee et al. 2008).

Besides the issue of scale and surprise, energy systems are also characterized by path-dependency. Path dependence is an attribute of complex social-ecological systems that depicts the influence of historical and other contextual factors on current and future system dynamics (Berkes 2007). In a narrower sense path dependence implies a self-reinforcing process in which actions taken in a given direction tend to induce further actions along the same path due to positive feedback mechanisms, thus making it almost impossible to switch to an alternative path (Pierson 2000). Path dependence has been widely used to describe the lock-in of fossil fuels in current energy systems and the difficulty of initiating change from the current system in spite of increasing recognition of the benefits of renewable sources of energy (Araujo 2014; Goldthau 2014; Spinardi 2015). Realization of the importance of path dependence suggests that policies aimed at enhancing the transition toward renewable energy sources in sub-Saharan Africa need to be context-specific, since each situation is unique and can only be understood within its historical context.

Promoting Integrated and Adaptive Management

Energy systems interact with other sectors across multiple scales. Given the uncertainties associated with these cross-scale interactions, policies aimed at enhancing the adoption of renewable energy technologies need to adopt an adaptive policy approach that allows for experimentation while preparing to deal with surprise (Jaccard et al. 2012). As has been previously discussed, adaptive management facilitates experimentation and monitoring as mechanisms for generating knowledge about complex social-ecological interactions. By monitoring the implementation of renewable energy innovations, and maintaining the flexibility for integrating new insights into subsequent decision-making, an adaptive management approach could build capacities for dealing with uncertainties in the adoption of renewable energy technologies. In sub-Saharan Africa where capacities in renewable energy technologies are poorly developed (Hancock 2015a), an adaptive management approach to developing and testing renewable energy technologies appears promising.

Besides prioritizing learning, an integrated approach to energy planning is also needed to harness the synergies and to reduce the trade-offs from the multiple scales of interaction (Lee et al. 2008; Hodbod and Adger 2014). For instance, policies aimed at promoting modern biofuels will need to be aligned with policies on agriculture, forestry and natural resource management in order to deal with the synergies and trade-offs (Lee et al. 2008). The pursuit of renewable energy policies based on such a holistic approach that safeguards the socio-economic needs of local communities, is critical to gaining the support and commitment of communities, and hence more likely to be successful. For instance, Ahlborg and Sjostedt (2015) present an insightful account of the successful implementation of a small-scale hydropower project in rural Tanzania with the support of an external non-governmental organization (NGO). The authors partly attribute the success of the project to the integrated approach adopted by the NGO, which included enhancing the productive use of electricity, as well as enhancing access to community services and benefits. Given the community-oriented goals of the project, substantial efforts were invested into building the capacity of the communities to manage the project. With regard to the outcomes, the authors conclude, "Local ownership has led to the project becoming an arena for community collaboration and problem solving, and creating values such as effective load management and protection of infrastructure" (p. 20). The finding that integrated approaches to energy planning are more likely to succeed at the local level suggests that regional energy planning initiatives in sub-Saharan Africa, such as the ECOWAS Centre for Renewable Energy and Energy Efficiency (Hancock 2015a) may need to be complemented with more targeted local level initiatives in order to realize these regional aspirations.

Utilizing Diverse Knowledge Systems

The dominance of engineering and economics in past energy research has failed to account adequately for the human dimensions (Sovacool 2014). As a result, the social and institutional factors influencing how individuals, households, communities and societies interact with energy systems are poorly understood. Social science disciplines, such as sociology, anthropology, and social psychology could potentially enhance current understanding on social interactions with energy systems at various levels of social organizations. In view of the growing appreciation of the social-ecological complexity of energy systems, cross-disciplinary approaches to research are increasingly receiving attention as means of understanding and solving complex energy problems, such as the transition toward renewable energy systems (Lee et al. 2008; Hodbod and Adger 2014; Hancock 2015b).

Eigenbrode et al. (2007) use the concept of cross-disciplinary research to refer to research that transcends the traditional boundaries of disciplines. Different levels of integration are entailed in cross-disciplinary work. In multidisciplinary research, "multiple researchers investigate a single problem, but do so as if each were working within their own disciplinary setting" (Miller et al. 2008: 3). Each discipline employs its own theoretical perspectives, methods, and interpretive standards to study questions or problems about a common system (Eigenbrode et al. 2007). Interdisciplinary research entails a greater level of coordination among disciplines in the various stages of the research process (Miller et al. 2008). Here, common terminology or methodology is formulated within a framework shared by all the disciplines involved (McNeill 1999). Transdisciplinary research involves the integration of disciplinary epistemologies and theoretical perspectives to address unique problems that could not be dealt with within existing disciplinary domains (McNeill 1999; Eigenbrode et al. 2007). While these cross-disciplinary approaches have the potential to enhance the explanatory power and policy relevance of energy research (Sovacool 2014; Hancock 2015b), they are also challenged by a range of factors, including institutional barriers in academia and governments that tend to favor traditional disciplinary research (Sovacool 2014). Differences in philosophical orientations, inquiry methodologies, theoretical frameworks and criteria for judging the quality of research also affect cross-disciplinary research (Lele and Norgaard 2005; Eigenbrode et al. 2007). Investing in capacity-building for cross-disciplinary research in energy systems through training programs could help overcome some of these challenges in knowledge integration in sub-Saharan Africa.

Besides the expansion of knowledge on energy systems through cross-disciplinary work, the integration of local and traditional knowledge into energy planning processes represents another opportunity for broadening the knowledge base of energy planning. Local ecological knowledge refers to "knowledge held by a specific group of people about their local ecosystems" (Olsson and Folke 2001: 87). Local ecological knowledge differs from traditional ecological knowledge, which refers to the body of knowledge and beliefs that local communities have accumulated over time and passed down through cultural transmission across generations (Berkes et al. 2000; Olsson and Folke 2001). Sovacool (2014) has identified a range of benefits associated with participatory decision-making processes that allow for the utilization of indigenous knowledge in energy research, including responsiveness to ethical and moral concerns, avoidance of conflict, enhancement of democratic decision-making, as well as public support for planning outcomes. However, utilization of local knowledge can be constrained by a range of barriers, including the lack of trust and equal recognition of local and traditional knowledge, as well as epistemological challenges in the integration of traditional knowledge with western science (Berkes 2009; Armitage et al. 2012). In sub-Saharan Africa, where local communities have accumulated rich experience in the use of renewable energy sources such as biomass, concrete steps need to be taken to ensure that traditional knowledge is not marginalized in energy planning processes.

Multilevel Institutions

Traditionally, energy systems have been characterized by large, scale infrastructure, as well as centralized ownership and decision-making procedures (O'Brien and Hope 2010). However, there is increasing realization that the transition toward renewable energy sources will require a more decentralized approach to energy policy and infrastructure development (ibid). More innovative institutional mechanisms are needed for connecting the diversity of actors across scales and sectors engaged in energy planning processes (Sovacool 2014; Christopoulos et al. 2016).

The attributes of institutional nesting and diversity from the adaptive governance literature provide a promising institutional structure for such multilevel stakeholder interactions. The nesting of different types of institutions within the adaptive governance framework provides a polycentric institutional structure (Marshall 2009). Polycentric institutions are characterized by multiple overlapping centers of decision-making authority across multiple levels with some degree of diversity and autonomy at each level (Koontz et al. 2015). The operation of polycentric institutions is based on the principle of subsidiarity according to which governance responsibilities are devolved to the lowest appropriate level for effective problem-solving (Marshall 2009; Cole 2015).

Polycentric institutional structures provide several benefits in the management of complex social-ecological systems, including the pooling together and sharing of different types of knowledge among actors to create awareness, providing opportunities for sustained interaction processes necessary for building social capital and shared values, and building capacities for adaptive management (Marshall 2009; Marshall and Smith 2010). Polycentric institutions also contribute to social-ecological resilience by providing opportunities for experimentation of new rules across multiple scales (Folke et al. 2011; Cole 2015), providing overlap and redundancies to reduce vulnerabilities to system failure (Koontz et al. 2015), as well as enhancing the fit between policy interventions and the scales at which problems occur (Olsson and Galaz 2009).

In view of these benefits, polycentric institutions are increasingly receiving attention as critical in the transition toward renewable energy sources (Sovacool 2014). A polycentric approach to renewable energy policy could provide opportunities for experimenting new innovations, sharing of information among stakeholders, devising context-specific energy solutions that match the scale of the problem, promoting the sharing of decision-making authority across scales, promoting cooperation, and enhancing the enforcement of rules and policies (Goldthau 2014; Sovacool 2014). In spite of all these potential benefits, the application of polycentric institutions to the governance of energy systems is likely to encounter some difficulties, particularly the difficulty of breaking down the dominance of centralized institutions and infrastructure (Goldthau 2014). Polycentric institutions can be difficult to consciously craft (Folke et al. 2011). Change may be resisted by vested interests, as well as the dominance of mental models that endorse the status quo (Marshall and Smith 2010). There is also the issue of high transaction costs in gathering and sharing information, as well as the difficulty of coordinating adaptive responses among the dispersed actors across multiple scales in a polycentric system (Huitema et al. 2009; Koontz et al. 2015).

In view of the challenges associated with pursuing a polycentric approach to energy policy, Goldthau (2014) notes that regulatory bodies typically focus on a chosen scale of intervention without adequate coordination of impacts at other scales. In sub-Saharan Africa, greater attention to building institutional capacity for energy planning at the local and provincial levels is needed to complement progress being made in the formulation of national and regional level policies on renewable energy.

Analytic Deliberation

The energy sector has a long history of being implicated in violent political conflicts in various regions, including sub-Saharan Africa (Sovacool 2014). Planning for renewable energy systems, just like other arenas of development and environment, is also characterized by conflicts and uncertainties. As has been previously noted, policies aimed at promoting bioenergy production, for instance, will also need to be coordinated with policies in other sectors in order to avoid adverse impacts. In pursing such an integrated approach, there are bound to be conflicting values among stakeholders, as well as knowledge uncertainties regarding the synergies and trade-offs among the various values. A promising approach to managing the trade-offs and synergies among the multiple goals at stake in such planning processes is to engage stakeholders in negotiation of political solutions rather than the imposition of decisions by technical experts (Nelson et al. 2008; O'Brien and Hope 2010). Lee et al. (2008) suggest that an appropriate role for government in energy planning is to facilitate such negotiation processes. Unfortunately, conflict management has not received enough attention in the energy sector (Hodbod and Adger 2014), and governments often lack the capacity to undertake these responsibilities (Lee et al. 2008).

The analytic deliberation process of adaptive governance offers promise for dealing with the wicked conflicts in energy planning processes. Analytic deliberation refers to decision-making processes that combine scientific analysis with public deliberation as a means of dealing with knowledge uncertainties and value conflicts (Dietz et al. 2003; Dietz 2013). Besides managing conflicts, the analytic deliberation process also offers a range of benefits, such as enhanced sharing of information, formation of social capital through interactions, and enhancing opportunities for participation, transparency and accountability (Akamani and Wilson 2011). Promoting effective stakeholder deliberation in planning processes for renewable energy in sub-Saharan Africa will require external support for building the institutional capacity for managing energy conflicts.

CONCLUSION

Countries in sub-Saharan Africa face various kinds of energy crises, including high dependence on imported fossil fuels, inefficient energy use, high dependence on traditional biomass, low access to electricity, as well as decaying and inadequate energy infrastructure. While the sub-region abounds in a range of renewable sources of energy, these resources remain underdeveloped and under-researched. Inadequacy of policy and institutional mechanisms on energy, as well as limitations in knowledge, skills and resources all contribute to a general lack of awareness, interest and capacity to develop renewable energy sources in sub-Saharan Africa. Although the transition from fossil fuel-based economies to renewable energy sources is generally known to be constrained by the path-dependent effects of prior investments in energy technologies, infrastructure, energy use habits and so forth, the relatively less developed energy infrastructure in sub-Saharan Africa presents an opportunity to leapfrog into economies based on renewable energy. Thus, there is urgent need for appropriate frameworks to guide the immediate development of policies for enhancing the energy transition process in sub-Saharan Africa. Enhancing the awareness, interest and capacity for the energy transition in sub-Saharan Africa will require the coordinated efforts of state and non-state actors across multiple scales, including local communities, decision-makers, scientists, as well as local and international NGOs. Adaptive and resilience-based approaches are needed in facilitating such social-ecological transitions in order to reduce vulnerability.

Using conceptual insights from research on social-ecological resilience and adaptive governance, this paper has examined key considerations that could potentially inform future policies on the development of renewable energy resources in sub-Saharan Africa. These include recognition of the complexity of energy systems, pursuing adaptive and integrated management goals to harness synergies and reduce trade-offs between the energy sector and other sectors across multiple scales, use of a diversity of knowledge systems to inform better decisions and to create broad-based societal awareness, promoting multilevel institutional structures for linking actors across scales, as well as using analytic deliberation processes as mechanisms for managing value conflicts and knowledge uncertainties. The adaptive governance approach holds promise for building the resilience and robustness of energy systems as well as reducing their vulnerability to climate change impacts and other uncertainties associated with social and ecological change. It must be noted that the ideas expressed in this article are necessarily broad, aimed at highlighting areas of general policy concern across the energy sector. The translation of these ideas into policies in specific situations will need to be selective and tailored to suit the policy context. Success in policy formulation and implementation will likely be enhanced where there is the political will and enabling legislation to promote flexibility and active stakeholder involvement in the various stages of the policy process.

ACKNOWLEDGEMENTS

The researcher would like to thank the issue editor and anonymous reviewers for their constructive comments on previous versions of the manuscript. The researcher is also indebted to the College of Agricultural Sciences at Southern Illinois University Carbondale for the financial support during the preparation of the manuscript.

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