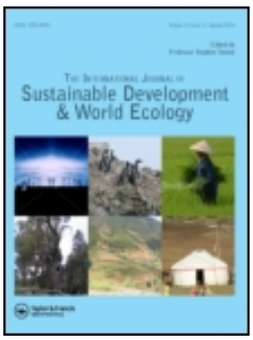

International Journal of Sustainable Development & World Ecology

ISSN: 1350-4509 (Print) 1745-2627 (Online) Journal homepage: https://www.tandfonline.com/loi/tsdw20

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To cite this article: Sheona E. Shackleton & Charlie M. Shackleton (2012) Linking poverty, HIV/AIDS and climate change to human and ecosystem vulnerability in southern Africa: consequences for livelihoods and sustainable ecosystem management, International Journal of Sustainable Development & World Ecology, 19:3, 275-286, DOI: 10.1080/13504509.2011.641039

To link to this article: https://doi.org/10.1080/13504509.2011.641039

International Journal of Sustainable Development & World Ecology
Vol. 19, No. 3, June 2012, 275–286

Taylor & Francis
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Linking poverty, HIV/AIDS and climate change to human and ecosystem vulnerability in southern Africa: consequences for livelihoods and sustainable ecosystem management

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People in southern Africa are facing escalating levels of risk, uncertainty and consequently vulnerability as a result of multiple interacting stressors, including HIV/AIDS, poverty, food insecurity, weak governance, climate change and land degradation, to name but a few. Vulnerability or livelihood insecurity emerges when poor people as individuals or social units have to face harmful threats or shocks with inadequate capacity to respond effectively. In such situations, people often have no choice but to turn to their immediate environment for support. Evidence suggests that rising levels of human vulnerability are driving increased dependency on biodiversity and ecosystem services, which in turn, and along with other threats, is rendering ecosystems more vulnerable. This paper explores the dynamic and complex linkages and feedbacks between human vulnerability and ecosystem vulnerability, drawing on data from the southern African region. Human vulnerability is conceptualized as a threat to ecosystem health, as driven by the interplay between a number of current and emerging factors. We focus on poverty, HIV/AIDS and more intense climate extremes as examples of stressors on livelihoods and direct and indirect drivers of ecosystem change. We discuss how some of the responses to increased vulnerability may pose threats to biodiversity conservation, ecosystem management and sustainable development, whilst considering potential solutions that rely on a thorough understanding of coupled social–ecological systems and the interplay between multiple stressors and responses at different scales.

Keywords: vulnerability; southern Africa; livelihoods; ecosystem services; HIV/AIDS; climate change

Introduction

It is widely recognized that the world today is becoming increasingly complex and uncertain as our planet undergoes escalating levels of environmental change, including climate change, and as globalization links countries and economic systems in multifarious and often unpredictable ways. Indeed, one of the only certainties when considering modern, coupled human–environment systems is uncertainty. Such uncertainty is a reality and an outcome of the rapidly changing context in which we find ourselves; a context in which novel threats to ecosystems, such as increased climate variability, changes in markets for commodities like biofuels and greater dependencies on ecosystem services, have emerged (Leach et al. 2010). Uncertainty can be viewed as one of the prime factors exacerbating vulnerability, particularly for poor people who often lack the capabilities and assets to cope with unanticipated events, especially when these arrive simultaneously with other stresses that they face on a daily basis (Adger and Vincent 2005; Hope 2009). Human vulnerability, in turn, can influence ecosystems and their resilience, as poor people frequently turn to natural capital for coping and insurance (e.g. Shackleton CM and Shackleton SE 2004; Ezebilo and Mattsson 2010; Takasaki 2011). Consequently, rising livelihood vulnerability is driving increased dependency on biodiversity and ecosystem services (Osbahr et al. 2008; Shackleton et al. 2010; Völker and Waibel 2010), which, in turn, is rendering ecosystems more vulnerable (Dovie et al. 2002; Malley et al. 2009). Indeed, vulnerability is often articulated at the local level in the deterioration of environmental and human health and well-being (O'Brien, Quinlan, Ziervogel 2009). Consequently, viewing complex social–ecological systems through a vulnerability lens can assist in conceptualizing the links between environmental and social change, livelihoods and ecosystem threats and thus illuminate pathways towards more effective ecosystem management and enhanced human well-being.

In this paper, we illustrate how human vulnerability and ecosystem vulnerability are intimately linked, and why understanding human vulnerability, its multiple causes and effects, is so important for sustainable development, the conservation of ecosystem services[1] and ultimately for human well-being. We start by building a conceptual understanding of the issues, including why the notion of vulnerability (and its antonym, resilience) is receiving increasing attention. We then review some of the most important drivers of vulnerability and change (stressors) in the southern African region, namely poverty, HIV/AIDS and climate change, and the responses to these, providing evidence that illustrates the link between human and ecosystem vulnerability. Finally, we reflect on what this means for rural livelihoods, sustainability and the links between ecosystem services and human well-being.

Understanding vulnerability and resilience

Vulnerability is a complex, somewhat malleable, concept with several definitions and applications across disciplines

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ISSN 1350-4509 print/ISSN 1745-2627 online

http://dx.doi.org/10.1080/13504509.2011.641039
http://www.tandfonline.com

and contexts. It generally includes ideas related to exposure to risk or shock and the capacity to cope with and recover from these shocks, as influenced by multiple environmental and, more particularly, social processes (Kelly and Adger 2000; Adger 2006; Wiegers et al. 2006). Essentially, there are three dimensions to vulnerability: (a) exposure, (b) sensitivity and (c) capacity to respond, or adaptability (Intergovernmental Panel on Climate Change 2007). From a human vulnerability perspective, exposure largely deals with the degree of exposure to external hazards and shocks such as floods, droughts, wars, disease, etc., which are beyond the control of the people affected. Sensitivity (or susceptibility to adverse effects – Adger 2006) indicates how at-risk a household or community is to the shocks and the likely degree of impact and change associated with these. It is largely defined through the assets people have, the activities and livelihood strategies they adopt (such as agriculture, fisheries), various internal social, economic and structurally related factors, and other contextual factors. Capacity to respond, or adaptive capacity, relates to the ability to deal with and recover from exposure to a shock or stress; vulnerable households or communities typically lack this capacity. This situation is sometimes referred to as 'defencelessness' (Chambers 1999) and could be thought of as a function of high sensitivity and low resilience (Gallopin 2006). The separation between 'endpoint vulnerability' – preparing for specific hazards such as floods – and 'startpoint vulnerability' – addressing the underlying causes of vulnerability such as poverty, inequity and poor accountability in institutions – is increasingly seen as artificial and unhelpful (Pettengell 2010). Now more popular understanding is that vulnerability or livelihood insecurity encompasses both of these views and emerges when poor people as individuals or social units have to face change in the form of harmful threats, stresses (enduring shifts) or shocks (transient disruption) with inadequate capacity or capability to respond effectively (O'Brien, Quinlan, Ziervogel 2009). Vulnerability is often used to highlight the specific contextual factors that influence exposure and the capacity to respond, in order to explain how and why some groups and individuals experience negative outcomes from shocks and stresses while others do not (O'Brien, Hayward, Berkes 2009).

In considering vulnerability, it is also necessary to define resilience, as building resilience is key to reducing vulnerability and enhancing adaptive capacity. Resilience is a fundamental concept in complex social–ecological systems thinking and refers to the situation where social–ecological systems, households or communities are able to respond to shocks and stresses and, moreover, use this as an opportunity for innovation and adaptation (Folke 2006). A widely employed definition relates to 'the capacity of a system to experience shocks while retaining essentially the same function, structure and feedbacks, and therefore the same identity' (Walker et al. 2006). Resilience is critical in preventing systems from crossing a threshold and moving into a different domain or state. More recently, the idea of self-organization or re-organization has also been included in the concept (Adger 2006). Resilience is often seen as the 'mirror' of vulnerability and analogous or related to adaptive capacity (Gallopin 2006). From a livelihood perspective, resilience is the capacity to cope with and adapt to stresses and shocks such that households do not become worse off or their ability to deal with future shocks compromised. Many factors are considered to be important in building resilience. From a livelihoods perspective, resilience may be reflected in the resources, knowledge and technologies that are available to households, the choices that are made, and the practices and innovations adopted to ameliorate the impacts of stressors, all mediated by institutions and the assets and capabilities upon which households can draw. Opportunities to build resilience in livelihoods (and thus reduce vulnerability) are considered in the final section of this paper. Unlike vulnerability, the concept of resilience adds a temporal 'forward looking' dimension that implies improved capacity to react to future, often unpredictable, change (Sallu et al. 2010).

Conceptualizing the links between human and ecosystem vulnerability

Shocks or risks to livelihoods may occur from global to local scales and may be environmentally or socially driven. The close interactions among environmental and social factors often make it difficult to separate them, with causal relationships and feedbacks creating a complex web of stressors. In southern Africa, the list is long and poor people across the region are exposed to numerous threats, stressors and sources of change (Shackleton et al. 2010). Such stressors have different effects on different households, and may work in synchrony to negatively influence livelihood outcomes, creating feedback loops leading to increasing vulnerability and food insecurity (Misselhorn 2005). The result is that some households may become trapped in a downward spiral of struggle, as one shock after another erodes assets, capabilities and savings. Too often livelihood shocks and stressors are considered in isolation from one another, instead of as an interlinked complex with feedbacks (Agrawal 2011). This tends to be the approach typical of climate change adaptation research and practice, where, for example, the focus will be on small-scale farmers and changes in weather patterns. However, 'it is increasingly evident that there is a complex interplay of factors shaping rural livelihoods at various scales' (Ziervogel and Drimie 2008). In many areas, changes in climate may affect the nature, magnitude and frequency of existing stresses such as drought or disease burden, while in other situations it may bring new uncertainty and hazards such as flooding (Ziervogel and Taylor 2008). It has been said that, 'many more people now live 'closer to the edge' in southern Africa than they did during the 1990s' (Maunder and Wiggins 2007). Accordingly, a key issue to appreciate is how these various stressors interact to influence livelihoods and vulnerability, and in turn, how this affects ecosystem processes and services (Figure 1).

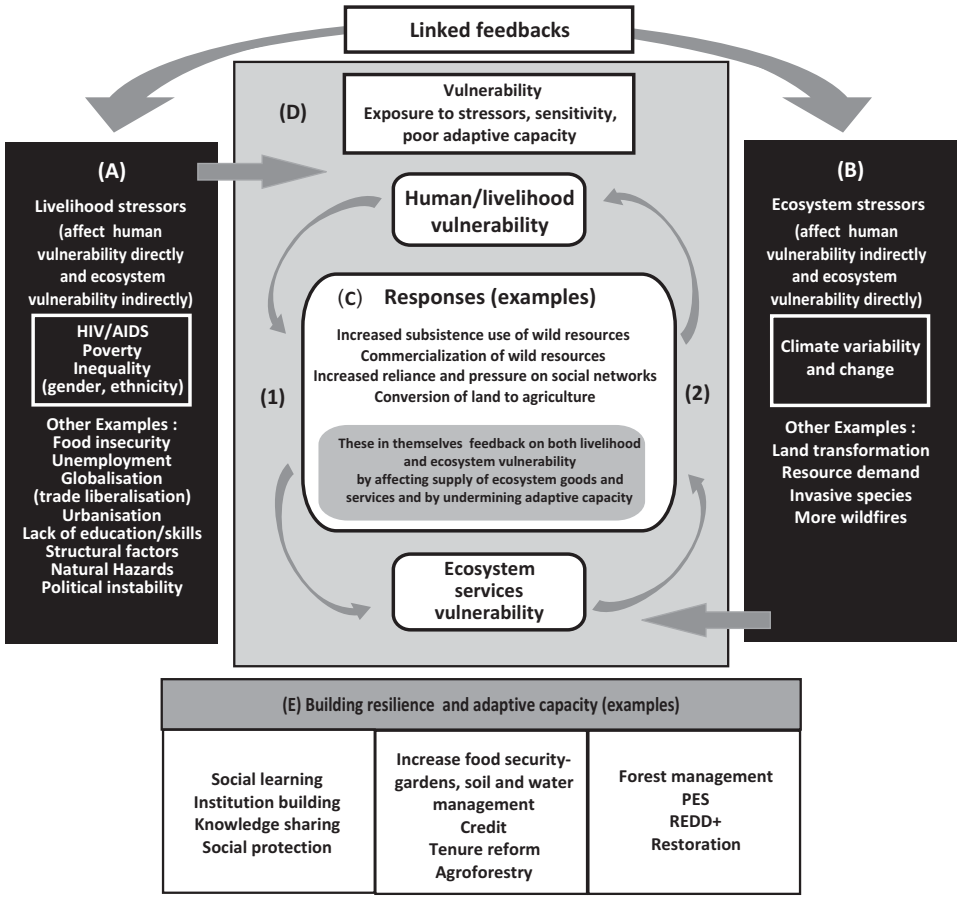

Figure 1. Conceptual framework illustrating the links and feedbacks between human/livelihood vulnerability and ecosystem service vulnerability as influenced by multiple stressors and responses. The shocks and stressors in highlighted in Boxes A and B, namely HIV/AIDS, poverty and inequality, and climate change, form the focus of this paper.
Source: Authors.

One way to think about links is to illustrate them using a conceptual framework (Figure 1). Poor rural people worldwide are facing escalating levels of risk, uncertainty and vulnerability as the dual result of (a) multiple and growing social and economic stressors that act directly on livelihoods (Box A), and (b) changes in critical ecosystem services brought on by threats such as climate change (Box B), resource degradation and increasing demand. The latter affect livelihoods and human vulnerability indirectly through their influence on agriculture and biodiversity. The area that most interests us in this paper is the relationship between increasing human vulnerability, driven by stressors such as poverty and HIV/AIDS, and people's livelihood responses that result in greater use and reliance on natural resources and ecosystem services (Box C, Figure 1). For instance, the Millennium Ecosystem Assessment (MA 2005) revealed that where human well-being diminishes (through exposure to stressors such as HIV/AIDS) there tends to be a concomitant increase in immediate dependence on ecosystem services (Arrow 1, Box D, Figure 1). The resultant increased pressure on natural resources often has negative feedbacks on the capacity of ecosystems to deliver these services, exacerbated by other stresses and threats on ecosystems (Box B, Figure 1). So, as vulnerability increases, contributions of ecosystem services to society are likely to become progressively more critical, but simultaneously more susceptible to loss (Völker and Waibel 2010). This can create a mutually reinforcing feedback loop that increases human vulnerability and ecosystem degradation (as illustrated by Arrows 1 and 2, Box D, Figure 1). Such a destructive cycle is expected to be accelerated through both (a) climate change (Wiggens 2003; Wiggens and Levy 2008) and (b) the responses to human vulnerability induced by multiple stressors, in particular HIV/AIDS in the region (Shackleton 2006; Shackleton et al. 2010). It is therefore critical to characterize and understand the components and feedbacks of these cycles. In particular, in southern Africa, priority needs to be given to understanding the interaction between vulnerability, poverty, food insecurity, HIV/AIDS and the environment, including climate change, to support livelihood and ecosystem resilience (Shackleton et al. 2010; see highlighted segments of Boxes A and B, Figure 1). It is these links that form the focus of this paper. Furthermore, to avoid the feedback loop and potential downward spiral described above and in Box D (Figure 1), it is necessary to build the adaptive capacity and resilience of the social–ecological system. Some

suggestions and examples to achieve this are made in Box E (Figure 1) and in the final section of the paper.

Examples of the links between human and ecosystem vulnerability

While it is relatively straightforward to develop a conceptual framework to depict the complexity of interactions and feedbacks amongst components of a system, the real test comes in demonstrating these links and feedbacks in reality and in finding ways to deal with the multiple connections. Thus, a key research and policy challenge lies in developing understandings of the various components of Figure 1 and their interactions, and how the interactions and outcomes change in the face of multiple simultaneous shocks or stresses. We start by considering three examples of single stressors of high significance in the region (namely HIV/AIDS, poverty[2] and climate change) and how they affect ecosystem services and natural resource use. Thereafter, we grapple with the additive or multiplicative effects of these working together simultaneously.

Although there are increasing numbers of studies from the region that demonstrate how vulnerable people turn to natural capital to cope with stress and shocks, there are fewer studies that measure the actual impacts of this increased use on ecosystems and the goods and services they deliver, especially at the local scale. At a regional level, the Southern African Millennium Ecosystem Assessment highlighted a decline in many ecosystem services in the region (Scholes and Biggs 2004; van Jaarsveld et al. 2005). It could be expected that, if ecosystems are already stressed and vulnerable, any increased pressure due to escalating human vulnerability would intensify this decline. However, the empirical question as to whether increasing human vulnerability is causing increasing ecosystem vulnerability has yet to be fully addressed, and is a key area for further research.

Poverty, inequality, vulnerability and ecosystem services

To understand how poverty drives patterns of use and reliance on ecosystem services, it is necessary to briefly define poverty and its extent in the region. Broadly speaking, poverty is articulated as the pronounced deprivation of well-being related to a lack of material income or consumption, low levels of education and health, poor nutrition and low food security, high levels of vulnerability and exposure to risk, and a profound lack of opportunity to be heard (Chambers 1988). This definition goes beyond just adequate income, to include aspects of security, independence, choice, health and well-being, and the ability to devise appropriate coping strategies when needed. The concept of human well-being is often used as an alternative for poverty because of its multi-dimensional nature and because poverty is still often described and measured in narrow income and consumption terms (Kingdon and Knight 2003; MA 2005). Overall, poverty is widespread throughout southern Africa, although there are marked disparities between countries, between regions within countries and between rural and urban populations; for example the proportion of the population living on less than US$1 per day varies from 24% in Botswana to over 50% in Zimbabwe (UNDP 2005).

It is increasingly appreciated that poor and vulnerable households and communities rely heavily on provisioning services in the form of wild natural capital as an integral component of their livelihoods (Dovie et al. 2002; World Resources Institute 2005; Ezebilo and Mattsson 2010). Such use can be for direct provisioning, as safety-nets in times of need and for income generation on an *ad hoc* or permanent basis. As such, poverty, through its effects on vulnerability, can be regarded as a driver of wild product use, with changes in poverty profiles being associated with changes in use of these products. If poverty deepens, then one can expect use of locally available provisioning services to increase, particularly for already vulnerable and poor households (Shackleton CM and Shackleton SE 2004; Völker and Waibel 2010). Conversely, should poverty decline, then direct use of some natural resources will decline as they are substituted by commercially available alternatives, although this is complicated by cultural traditions and consumer preferences (Cocks and Dold 2006). The importance of direct provisioning lies in it allowing poorer households to allocate scarce cash incomes to unsubstitutable goods and services such as education and health costs.

Evidence of this in southern Africa comes from multiple sources. For example, Shackleton et al. (2008) demonstrated across four user groups that a greater proportion of poorer households engaged in wild product trading than their wealthier counterparts. Additionally, the primary catalyst for entering this trade was a shock to the household, often the loss of income due to job loss or death of a breadwinner. Without the subsequent income from trading, households would be significantly poorer. In the case of several of the products, that traders mentioned, was a perceived decrease in the resource, and they attributed this to increasing numbers of users (Shackleton 2005). In terms of direct provisioning, Shackleton CM and Shackleton SE (2006) found that poor households consumed, on average, approximately 75% more fuelwood and 48% more wild edible fruits than wealthier households in the same village. This pattern is not restricted to remote or rural villages. For example, Brouwer and Falcão (2004) found that the lowest income groups in the capital city of Mozambique (Maputo) were more reliant on fuelwood as an energy source than the wealthiest groups. Similarly, Cocks and Dold (2006) reported that amongst urban dwellers in two South African cities, 76% of poor households used traditional plant medicines as compared to 53% of wealthier households. There is also a cultural dimension to these preferences, indicating that poverty is not solely the driver of the use of and reliance on provisioning services. In terms of supporting services, an example can be given of small-scale and subsistence agricultural production in which

poorer farmers rely more on natural soil fertility because they are less able to afford commercial fertilizers. But they may adopt innovative approaches to manage soil fertility, such as importing nutrients in the form of leaf litter, ash from fires or nutrient-rich soil from termite mounds, and planting a range of crops in different parts of their land to take advantage of the different levels of inherent soil fertility across their fields (Verlinden et al. 2006).

The safety-net function of provisioning services is particularly instructive for discussions around coping strategies in the face of shocks and stresses because it is invoked in times of negative changes in household circumstances (Paumgarten 2005), which allows a very clear examination of cause and effect, or driver and response, at a time of increased vulnerability. Wild natural resources can be invoked as safety-nets via three means (Shackleton CM and Shackleton SE 2004): increased use of a resource already an integral component of livelihoods; adoption of a resource that is not usually used; and temporary trade in wild products, which may evolve into a permanent livelihood strategy. Osbahr et al. (2008) reported that in a sample village in Mozambique the most widespread coping response to shocks was sale of crops, with the second-most common being sale of crafts and utensils made from wild resources. This echoes the findings of Paumgarten and Shackleton (2011) who examined coping responses of wealthy and less-wealthy households in two rural villages in South Africa. Amongst poor households, use of wild products was the second-most common strategy in coping with shocks (after turning to kin), whereas for the wealthier households it was the fifth-most common strategy. Moreover, 20% of the poorer households took up trade in wild products in response to the shock, but none of the wealthier households did so. This corresponds with a high proportion of poorer households generally involved in wild product trading in southern Africa (Pereira et al. 2006; Shackleton CM and Shackleton SE 2006; Shackleton et al. 2008; Paumgarten and Shackleton 2009). In Chivi, Zimbabwe, cash from sales of woodland products provided on average 15% of total income for 'very poor' households, but less than 1% for wealthy households (Campbell et al. 2002). Typically, the proportional contribution to livelihoods from trade in natural resources is several times higher for poor and female-headed households than wealthier ones (Pereira et al. 2006; Shackleton et al. 2008).

HIV/AIDS, vulnerability and ecosystem services

The past 10 years has seen greater awareness of the interconnectedness between population, health and the environment, with the links between HIV/AIDS and ecosystem services receiving specific attention in southern Africa due to the severity of the epidemic in the region (Hunter et al. 2007; Kaschula 2009; McGarry and Shackleton 2009a; Bolton and Talman 2010; Niehof et al. 2010). Bolton and Talman (2010) identified the following themes as the most important in linking these two areas: food insecurity, natural resource use, agriculture and land tenure issues, fisheries, gender issues, vulnerable children and the human capacity impacts of HIV/AIDS. In this section, we focus primarily on the links between HIV/AIDS and ecosystem services, especially wild resources.

Southern Africa has the highest incidence of HIV in the world, with prevalence rates of between 20% and 30% for females presenting at antenatal clinics (UNAIDS 2007), but can be higher at specific localities. It is the leading cause of death in the region; estimated at approximately 670,000 deaths in 2007 (UNAIDS 2007). With the majority of deaths being of prime-aged adults, the effects are felt throughout the family and at community and societal levels, through all spheres of endeavour including the social, economic and ecological. HIV/AIDS affects agricultural labour and productivity and hence food security; it results in reduced household cash incomes and so increased income poverty; loss of a breadwinner or multiple adults in the household frequently results in sale of household assets, thereby diminishing capacity to recover from other shocks; and in areas with high prevalence rates the formal healthcare system is overwhelmed, requiring increased home-based care, which diverts household labour from economically or agriculturally productive activities (Wiegers et al. 2006).

At the household level, the effects are longer lasting than other causes of mortality for two reasons. First, because so many families are affected, the traditional coping strategies (such as support from relatives) have been eroded (Misselhorn 2005; Shackleton 2006). Second, with the significantly higher death rates of prime-aged adults, the number of single-parent and child-headed households and orphans has grown (Misselhorn 2005). There are now almost 5 million orphans in the region, many of whom have dropped out of school and so the effects will last for the rest of their lifetime, if not generations. In the absence of adult caregivers, these children are particularly vulnerable to exploitation, abuse and HIV infection themselves. For example, in Zimbabwe, 'girls, especially those from child-headed households, have been forced into commercial sex, early marriage or child labour as a means of survival' (UNICEF 2004).

Thus, HIV/AIDS is probably the most insidious and significant current driver of vulnerability in the region. For example, Kgathi et al. (2007) reported from village focus group discussions in rural sites in Botswana that respondents felt that the HIV/AIDS epidemic was the most devastating shock they had ever experienced, not comparable with other livelihood shocks, since it resulted in illness and death. All members of the focus groups mentioned that they had experienced death of either a household member or a close relative due to HIV/AIDS. Particularly noteworthy when considering issues of vulnerability was that they stated that shocks such as drought, desiccation of river channels and damage to crops by wildlife also had adverse effects on their livelihoods, but these impacts did not compare with those of HIV/AIDS. Barany et al. (2005) and Kayambazinthu (2005) worked at several sites in Malawi

to document perceived changes in rural livelihoods generally over a 5-year period. The three most prevalent changes reported were (a) HIV/AIDS illness and death, (b) increased number of orphans and (c) higher costs of fertilizer. There is growing evidence that a key response to the vulnerabilities posed by HIV/AIDS has been an increased reliance on ecosystem services, both for direct household consumption and for sale to generate cash income. Guveya and Sukume (2003) modelled the livelihood impacts of HIV/AIDS deaths in rural households in Zimbabwe, and reported that all variations of the model parameters indicated a profound increase in poverty due to reductions in labour availability. For households where the death was of an adult female, food and income security were seriously jeopardized.

Evidence of increased demand for ecosystem services due to HIV/AIDS impacts comes from a growing suite of studies. For example, McGarry and Shackleton (2009a,b) examined the food procurement patterns of children in households with high HIV/AIDS proxy measures as opposed to households with low proxy measures. Rates of hunting of wild animals, birds and insects were significantly higher in highly affected households compared to unaffected households. In a 2-week monitoring period the consumption of wild mammals was three times higher, wild birds two times higher, reptiles almost double and insects four times higher. In qualitative work by Hunter et al. (2007) in South Africa, one respondent was recorded as saying that 'locusts are now our beef', an indicator of increased reliance on wild foods, while more recent quantitative data have shown higher levels of natural resource dependence among mortality-affected households accompanied by shifts in collection strategies (Hunter et al. 2011). Similarly, Challe and Price (2009) showed that the number of collection trips per week for wild edible orchids in southern Tanzania was double in HIV/AIDS affected households relative to unaffected ones. Moreover, 68% of HIV/AIDS affected households rated collection of wild orchids for consumption or for sale as their primary livelihood activity, whereas none of the unaffected households listed the activity as such, with 90% of them stated that agriculture was their primary livelihood. In Zimbabwe, Mutenje et al. (2010) found, using econometric models, that households affected by HIV/AIDS shocks 'practiced distress-push diversification by harvesting non-timber forest products'. In Botswana, Ngwenya and Kgathi (2006) reported that water use requirements of households with people living with HIV/AIDS increased on average by over 70% and that when water supply was interrupted households with AIDS sufferers experienced considerably greater difficulties than non-affected households.

In direct treatment of HIV/AIDS-related illnesses, Dold and Cocks (2002) reported that 54% of traditional healers interviewed indicated an increase in the number of patients they had attended to over the past 5 years, and that 81% expected a further increase in the next 5 years because of the HIV/AIDS pandemic. Moreover, 90% of these healers indicated that the availability of certain important medicinal plants used for the treatment of HIV/AIDS-related illnesses had declined over the past 10 years. In Malawi, Barany et al. (2005) and Kayambazinthu (2005) reported that fuelwood use increased more in households with a recent prime adult mortality than households where no such death had occurred. Hunter et al. (2007) described how some people's lives had changed, as they now had to collect fuelwood for cooking because they could no longer afford to purchase alternatives, or that the burden of collection had increased because there were fewer people in the household to assist. All of these examples illustrate the effects of HIV/AIDS as a stressor and driver of change, and how households turned to one or more ecosystem services as a means of coping, with recent work indicating that this may well be reliant on sufficient levels of local ecological knowledge (Weyer 2011). In instances where the resource base or service is compromised, then these sorts of coping mechanisms will be limited and household sensitivity to HIV/AIDS impacts heightened.

With respect to increased trade in wild products there is less direct evidence, with most studies reporting poverty as a primary driver of engagement in natural resource-based trade (Shackleton et al. 2008), although in many instances the initial catalyst or push-into poverty was the death of a breadwinner (Shackleton 2005; Weyer 2011). Thus, it is reasonable to hypothesize that because HIV/AIDS exacerbates poverty, it is also one of the primary drivers of wild product sales. McGarry and Shackleton (2009b) found that significantly more of the most vulnerable non-school-going orphans in their sample were commercializing wild foods. Wiegers et al. (2006) reported on the increased incidence of beer brewing and sales in households with HIV/AIDS sufferers, whereas, as already mentioned, Challe and Price (2009) found more HIV/AIDS affected households to be engaged in the trade of wild edible orchids than unaffected households.

Climate variability and change, vulnerability and ecosystem services

Climate variability and change is a critical driver of uncertainty in arid and semi-arid southern Africa, where models predict an increase in variability of rainfall and a decrease of up to 25% in available water resources in the next several decades (IPCC 2007). Overall, the region is likely to become hotter and drier, with increased annual rainfall volatility – one of the few regions in the world to do both (Hope 2009; Stringer et al. 2009). Tadross et al. (2006) have shown that there may be links between climate change and the reduced length of rainfall seasons in southern Africa. There is also evidence of shifts in the timing of peak rainfall to later in the season. Such uncertain precipitation patterns increase the risks associated with rain-fed agriculture and with pastoralism, and will have profound effects on a range of ecosystem services. Projected threats include heightened water scarcity, more intense droughts and floods, faster disease transmission, decreased farming productivity, migration of farmers to higher latitudes as

crops approach their viable temperature ranges, and loss of biodiversity (Lane et al. 2005; Stringer et al. 2009). While climate uncertainty has always been a key factor in these dryland environments, it is expected to become more extreme, as well as its effects exacerbated by other changes and trends, such as environmental degradation and desertification, water scarcity and existing food security challenges (Wiggens and Levy 2008; Malley et al. 2009; Stringer et al. 2009; Kumssa and Jones 2010).

In a series of over 80 in-country expert consultations for a large regional study on ecosystem services and poverty, Shackleton et al. (2010) revealed that informants perceived rainfall patterns to be changing, but sometimes were not sure if this was due to global warming or long-term cyclical patterns in climate. In Mozambique, it was said that rainfall is becoming more erratic and less concentrated in the rainy season, and that there is an increasing cycle of droughts and floods. The country was hit with three natural disasters in the 2007 growing season – flood, cyclone and drought. Cyclones are likely to become more intense and the belts are expected to move further south. Floods in Namibia are thought to be increasing, with floods in the Caprivi and Hardap Dam area in 2006, and again in 2010. Greater frequency of droughts was mentioned throughout the region (although the scientific evidence does not support this – Stringer et al. (2009)). The trend in increasing fire incidence in the dry forest areas, while driven by a number of factors, could be exacerbated by the more extreme weather conditions and greater drying and high winds towards the end of the dry season. In Botswana, it was pointed out that a shortening of the rainy season is already impacting on planting patterns, and that climate change is expected to disrupt ecotourism values associated with the Okavango Delta.

Despite the above perceptions, little is currently known about how climate change or variability is directly influencing livelihoods in the region, and how it links to some of the other stressors mentioned. Climate change, however, is likely to have direct impacts on ecosystem services and increase resource scarcity (Figure 1), which will erode one of the key safety-nets that poor rural people in southern Africa turn to during periods of hardship (MA 2005; Pettengell 2010; Shackleton et al. 2010). The predicted climate uncertainty will thus amplify risk amongst the most vulnerable members of society; those who are barely able to cope with current climate hazards and other insidious shocks such as HIV/AIDS, let alone future threats associated with global climate change (Huq and Ayers 2008).

In terms of evidence of the links between ecosystem and human vulnerability in response to climate change, Mizuno and Yamagata (2005) argued that in the arid regions of Namibia and Botswana even a slight increase in temperature or change in precipitation could produce a striking change in vegetation, exacerbating the already human-induced trends in the rangelands. This change in turn becomes a feedback loop, and the effects continue to increase. They have shown how the availability of a critical wild food used by both humans and livestock – the wild melon *Acanthicyos horridus* – has dwindled due to ecosystem impacts in the Kuiseb River region of Namibia. This plant grows extensively in fields in the lower reaches of the river, providing not only food but also cash income from sales of the seeds for food and oil. However, the growth and production of this species has declined recently because of a lack of floodwater in the river after the construction of a dam upstream. Floodwater is vital for the regeneration of this important food species. Climate change will only worsen the situation. Of concern is that these observations are made in the context of arguments that climate change in these desert regions is likely to substantially increase reliance on locally adapted natural resources, particularly wild foods, wildlife and a range of hardy products that demonstrate good market potential (such as some of the desert medicinal plants) as introduced breeds and crops become beleaguered under a harsher climate (Madzwamuse et al. 2007).

At a community level, several studies reveal how people may turn to new ecosystem services in their effort to cope with climate-induced stresses. Osbahr et al. (2008), for instance, found a number of generic, 'graded' responses to a variety of common climate-related stressors in Nwadjahane village in Mozambique, as summarized in Figure 2. Most of these were related to leveraging social and natural capital. For example, in terms of the latter, people consumed more wild resources (partly as a conservation of assets response), exchanged ecosystem goods, and sold dried fish, mats, herbal medicines, fruit and cashews in towns in response to increasing severity of climate events.

Similar results were found in a recent study from Sallu et al. (2010) in two rural areas of Botswana. Through the analysis of time-series data, their study suggested that rural communities are facing increasing environmental change, as manifested in more droughts, late-onset of rainfall and increased unpredictability of rainfall events, land degradation and, in one of the sites, the drying of a lake and cessation of flood recession cultivation. Different responses to these stressors were identified for different groupings of households. Livelihood diversification was a common response amongst about one quarter of households. Diversification activities included craft production and hunting, especially amongst the Basawra (San). This inclusion of wild products in their livelihood strategies rendered them more resilient than households focused only on cultivation and livestock production. The remaining households were extremely vulnerable and dependent on government social security benefits or employment from other community members. These households lack resilience, with many not managing to recover properly from a drought that happened almost two decades ago.

In contrast to the several, often group-specific, responses described above, a study of small-scale crop farmers in the dry north of South Africa (Byran et al. 2009) showed that, despite perceptions of warming and rainfall decline, few farmers (25%) were embracing adaptation strategies. Amongst those that were, the most common

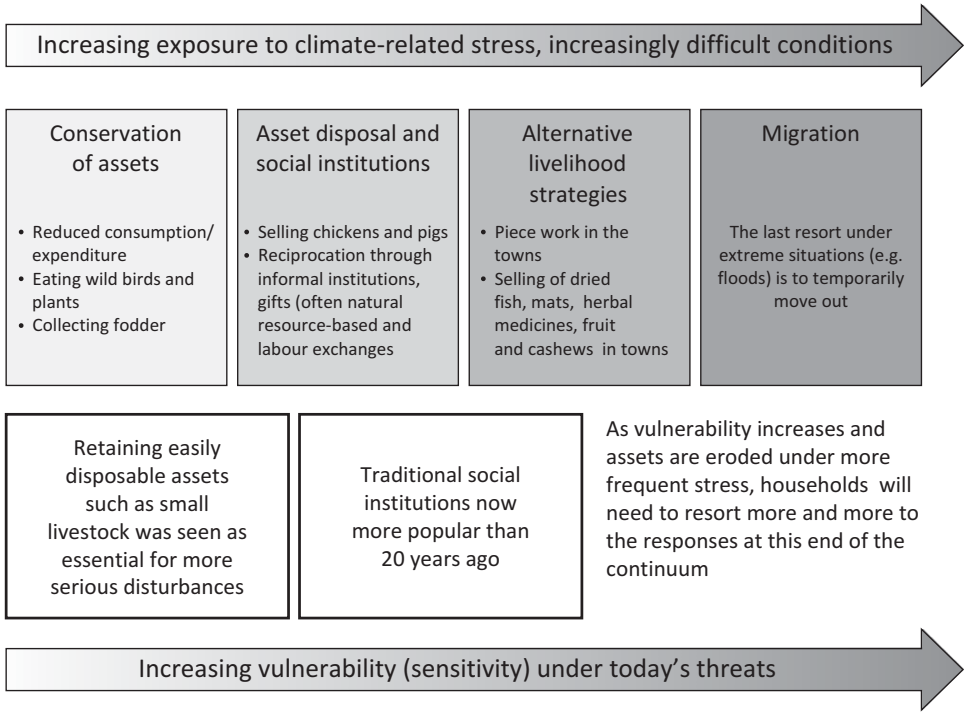

Figure 2. Responses to common climate-related stresses in a communal area of Mozambique.
Source: Summarized in figure format from Osbahr et al. (2008).

response was to increase irrigation. Such a response could be termed a mal-adaptation as it would just serve to exacerbate feedbacks on ecosystem services. The constraints or factors that prevent poor people responding to risk and uncertainty, which may include the need for information and learning on how to change, are therefore as important as understanding current adaptation practices.

Linking stressors and developing an integrated picture

In grappling with how the above three stressors interact to create vulnerability, the situation becomes more complex, yet at the same time the links are often logical. Bolton and Talman (2010) in their review identified three factors that affect all aspects of the AIDS–environment interface: social disruption, poverty and gender. They found these set the stage for enhanced susceptibility to HIV and increased reliance on ecosystem services to meet the needs that arise from the impacts of HIV/AIDS. They see coping capacity as critical and affected by the above factors. Decreased coping capacity makes households more vulnerable to HIV infection as individuals partake in risky behaviours. Infection, in turn, leads to increased dependence on ecosystem services for all the reasons mentioned above. This reliance, in turn, makes people more 'exposed to the vagaries of nature, weather and availability of resources' (Bolton and Talman 2010). Furthermore, when the effects of climate change are superimposed on this situation, communities' and households' coping mechanisms are further weakened, again predisposing them to infection: 'the effects are self-reinforcing and reciprocal' (Bolton and Talman 2010).

Similarly, poverty and gender are seen by Pettengell (2010) as the primary factors determining vulnerability to climate change and constrain coping and adaptive capacity: 'poverty, more than any other factor, determines vulnerability to climate and other environmental change and limits adaptive capacity'. Moreover, existing inequalities combine with poverty to magnify women's vulnerability through limiting the choices they have (Pettengell 2010). Access to and control over aspects of livelihoods such as land and natural resources, a safe place to live, finances and credit, healthcare, information and knowledge, education and personal mobility are all important in determining the ability to respond to and recover from new threats and stresses, but are generally limited amongst the poor. Addressing such underlying causes of poverty is therefore essential in tackling vulnerability and building capacity to cope with change and uncertainty (Scott 2008). With HIV/AIDS increasing poverty in southern Africa, for instance HIV/AIDS in South Africa contributes to the chronic impoverishment of 26–33% more households than would be the case in its absence (Aliber 2003), then vulnerability to climate change simultaneously intensifies. The poverty link is thus probably one of the most important in the human–ecosystem vulnerability nexus (Figure 1).

Implications for sustainability, ecosystem management and human well-being

One of the most obvious outcomes of this analysis is that poor people's vulnerability context, the uncertainties and change they are facing, and the drivers or factors influencing this need greater attention (Lahsen et al. (2010)

mention that research in this area is underdeveloped). More fundamentally, we need to have an understanding of people's own perspectives on their vulnerability, which may be different to those of external stakeholders (Ziervogel and Taylor 2008; Leach et al. 2010), and may be influenced by their location and specific circumstances. This suggests a need for more local-level studies, similar to those of Osbahr et al. (2008). Furthermore, the analysis emphasized that few stressors act alone and indeed climate change, as the most prominent driver of uncertainty today, interacts with a multitude of other social and environmental threats and shocks to result in a variety of livelihood impacts. This means it is necessary to develop a sound understanding of the complex interplay between the various stressors that shape livelihoods and vulnerability among different households and at different scales (Misselhorn 2005; Lahsen et al. 2010; Agrawal 2011). HIV/AIDS has different impacts on households over time, with most attention focused on assisting AIDS sufferers while ill, but little support given to assisting surviving household members to get their lives together again after a death in a context of increasing risk (Ziervogel and Drimie 2008). The background vulnerabilities that increase the risk of HIV/AIDS may also be intensified by climate-change-induced vulnerability. For example, greater food insecurity may result in increased sexual favours for food (Bryceson and Fonsesca 2006).

The examples of evidence of the links between human and ecosystem vulnerability illustrate how closely they are intertwined. It is therefore vital to fully appreciate the dynamic interactions between household livelihoods and ecosystem services and how and in what circumstances people may use the environment as a safety-net and a means to cope and adapt. There are clear gaps in understanding (Shackleton et al. 2010). For example, Dube and Sekhwela (2007) emphasize the need for more research on resource endowment, indigenous knowledge systems and socio-cultural heritage capital in the context of climate change adaptation. In situations where people turn to natural resources in response to stress and vulnerability, there has been little work to measure how this use is impacting the species/natural resources of interest and the ecosystems from which they are harvested. Where there is evidence of negative impacts, this is mainly indirect and reflected in increased harvesting times and distances covered to locate products. In light of this, it is of note that the UK Ecosystem Services for Poverty Alleviation programme of DFID, NERC and ESRC (http://www.nerc.ac.uk/research/programmes/espa) is investing considerable funds into improving understanding of the links between poverty and ecosystem services globally.

From a more development perspective, there is a need to assist in building resilience and adaptability to uncertainty and change. Adaptation, development and poverty alleviation are linked transformational processes (Ziervogel and Taylor 2008; Pettengell 2010), which should not be thought about separately (McGray 2009). Interventions should, where possible, address underlying development needs, assist in poverty alleviation and support and build on existing activities and practices, as well as introduce new adaptive strategies (Hope 2009; Shackleton et al. 2010). Some examples of actions suggested in a project that considered AIDS and environment in the context of climate change (Ziervogel and Drimie 2008) include institution building (home-based care-giving groups, orphanages), food security support (communal gardens, wild foods – there was increased interest in knowledge on locally available foods), income-generating projects, renewable energy projects that reduce the amount of labour required for fuelwood gathering and protection of the resource base as a form of insurance and resilience (Box E, Figure 1). Carbon biosequestration projects (restoration, tree planting and REDD+) and other payment for ecosystem services initiatives could bring extra income into communities, as well as maintain ecosystem services; there are already several examples of such projects (e.g. Pettengell 2010). Soil and water management conservation practices can help in securing food security and in building resilience, as can agroforestry and crop diversification (including a mix of varieties of the same crop) and improved extension services targeting new groups in the form of vulnerable women, the elderly and orphans (Ziervogel and Drimie 2008; Pettengell 2010). Land and resource tenure security is of concern particularly to survivors of AIDS-affected households; the practice of depriving widows and orphans of productive assets is becoming more common in the region (Ziervogel and Drimie 2008). Credit and loans for difficult times and for livelihood diversification can reduce risky behaviour, and help households tide over after resources have been depleted caring for an ill household member. While these suggestions relate specifically to the HIV/AIDS context, all are appropriate for addressing human and ecosystem vulnerability in general.

Another important issue that is fundamental in addressing the uncertainty that prevails today is the need to assist communities and institutions to learn how to adapt, as much as any specific adaptation intervention (Pettengell 2010; Tschakert and Dietrich 2010). This is essential to building resilience and introduces the concept of social learning and more recently 'anticipatory learning' (Tschakert and Dietrich 2010). Social learning is any course of action that involves a series of social interactions and processes between actors within a social network and that has two main outcomes: (a) a change in understanding and behaviour amongst actors on the issue of concern; and (b) the uptake and location of this change within wider social units and communities of practice (Shackleton et al. 2009; Reed et al. 2010). Thus, to build adaptation capacity and break the cycle of mutually reinforcing human and ecosystem vulnerability it is necessary to learn how best people learn, use knowledge, take action and change their practices through the study of social and other learning processes. This is another gap in understanding and an area wide open for innovative and action-based research as new

methodological frameworks are advanced for understanding how people use knowledge, learn and modify their behaviour in the face of uncertainty (e.g. Tschakert and Dietrich 2010). We need to move from vulnerable people being passive victims in the face of change to active agents with access to the knowledge needed for reflective decision-making and adaptation (Tschakert and Dietrich 2010).

The discussion above reveals that addressing vulnerability in complex social–ecological systems will require new relationships between organizations, groups and individuals who may not have previously collaborated nor recognized the need (Ziervogel and Drimie 2008). For example,

> stakeholders working on issues such as natural resource access and utilization and land rights might consider how their beneficiaries are impacted by HIV/AIDS at the same time as educating those involved in 'HIV/AIDS responses' on the links and importance of approaches that are environmentally sustainable. (Ziervogel and Drimie 2008)

More cooperation will thus be needed between those concerned with human welfare (e.g. health officials and practitioners, social workers, poverty researchers) and those working in the areas of ecosystem health and management (e.g. climate change researchers, environmental managers, environmental scientists, agricultural officers). Furthermore, interaction between different scales of intervention and response is required from the national to local level. Pettengell (2010) argues that adaptation at the local level requires both bottom-up and top-down approaches: 'making a change at the local level requires community-based action supported by high level political will and devolved resources and decision-making'. Local government is a key institution that should be targeted as a facilitator in linking bottom-up and top-down processes.

In conclusion, clearly there is no easy 'quick-fix' solution to the prevailing nature of stressors such as HIV/AIDS and climate unpredictability. Long-term and concerted effort that brings together multiple stakeholders, from individual community members to practitioners, researchers, local government officials and councillors, government policy strategists and politicians in an environment of mutual learning will be required to find solutions and build resilience in an increasingly complex and uncertain world.

Acknowledgements

We thank both the University of Florida and the Latin American Studies Association (LASA) for the invitation and financial support to attend the conferences that resulted in the development of this paper. Further funding was provided via a South African National Research Foundation (NRF) research incentive grant awarded to Sheona Shackleton. In addition to the UF conference, the ideas in the paper were also inspired by the thinking that went into the proposal development for a recently granted IDRC project on vulnerability, climate change and HIV/AIDS. The authors thank reviewers of this paper for their insights and suggestions.

Notes

1. We use the MA typology of ecosystem services that recognizes: (a) provisioning services (e.g. fuel, fibre, medicines, food); (b) regulating services (ecosystem processes); (c) cultural services (the cultural, educational, spiritual, and recreational benefits); and (d) supporting services (the basic services underlying all others – e.g. primary production, soil formation) (MA 2005).
2. Poverty can be conceived as a cause, component and a consequence of vulnerability. The three are not easily separated. Here, we consider poverty primarily as cause, but also a component, of vulnerability.

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