TEMPORAL DIMENSIONS OF HUMAN ENVIRONMENTAL RESEARCH: ADAPTIVE CAPACITY IN RURAL SOUTH AFRICA

Sam Schramski
Environmental Studies Program
University of Colorado Boulder, CO 80303, USA
sasc4825@colorado.edu

Abstract
This article explores the problem of studying the temporal dimensions of human-environmental interactions, especially in light of not having available longitudinal data. We utilize a methodology that highlights the past, present, and future, in order to approximate these kinds of results in rural South Africa. The present is measured in the form of livelihood surveys. For the past, oral histories were conducted with elderly people in four villages to acquire information about past adaptive strategies. For the future, focus groups and fuzzy cognitive maps (FCM) of household participants in a workshop setting were conducted so as to understand what adaptations they envisage. We found that present conditions for adaptive capacity do not always align with those described in the past or envisaged for the future, but linkages emerge in a number of instances. Studies like this provide a means for temporal analysis without necessitating the use of longitudinal data.

Keywords: climate change, adaptation, environmental science, temporal analyses, longitudinal, South Africa

Introduction

For more than three decades researchers of global environmental change have been calling for interdisciplinary programs that tackle the complexity inherent in changes to the Earth's climate, biodiversity, soil quality, water, and food resources (Schneider, 1977). Scientists from both the social and ecological sciences have long argued that nature and society are not separate entities but rather interactive (e.g., Ratzel, 1 8 82; Wissler, 1926; Steward, 1955; Rappaport, 1967; Odum, 1971). Thus, nature-society dualisms are often artificial and require theories and methodologies from each domain. Climate change research has long explored geographic scale mismatches (e.g. Salih, 2012), but time has received far less attention (Adger et al., 2009). Adaptive capacity is addressed using a temporal approach as a means of understanding social-ecological changes. Local communities in South Africa have a history of adapting to shocks, such as alterations in national policy changes, disease, economic crises, and climate variability. Understanding how households have adapted in the past informs how they will adapt in the future. Through an examination of the future we assess overall lessons learnt from the past as well as the options these households envisage for their adaptive capacities.

Defining and measuring capacity over time

The Intergovernmental Panel on Climate Change (IPCC) refers to adaptive capacity as the "ability or potential of a system to respond successfully to climate variability and change, and includes adjustments in both behavior and in resources and technologies" (Parry et al.,

2007). Nevertheless, this is not the only definition. Authors from the social-ecological field, such as the authors of *Panarchy*, state that adaptive capacity is "the ability to confront uncertainty and develop an understanding of what contributes to loss" (Gunderson and Holling, 2001). It is in keeping with this definition that the 'potential' represents a society's response to the uncertainty brought on by climate change and variability. Much like thinking within modal logic (Shields, 2012, 402), not all potentials are possible and therefore infinite. 'Abilities' mean present responses or what was actually occurring at the time of research, given the available potentialities. This is a lens to understand adaptive capacity in the rural Eastern Cape province of South Africa. Drawing on the large body of literature dealing with rural livelihoods in the region (e.g., Cousins, 1999; Cocks and Wiersum, 2003; Shackleton and Shackleton, 2004), we focus on livelihood diversity, household health, and perceptions of environmental change to measure adaptive capacity. Previously, adaptive capacity was considered a function of livelihood diversity (Turner, Davidson-Hunt, and O'Flaherty, 2003; Adger et al., 2005; Uy, Shaw, and Takeuchi, 2008; Perz et al., 2012), as well as health and wellbeing. These were most closely linked together in case studies on water and health (Ebi & Sebenza, 2008; Bunch, 2011).

Identifying *potential* in the study allows an incorporation of the strengths of explanation from the social sciences. Neither the social nor the biophysical sciences have substantively investigated how local people demonstrate adaptive capacity through a multi-temporal mixed methods approach and so the finer points of each set of contingency is not necessary to elucidate. With this in mind: (1) even if a researcher is presented with longitudinal data, defining adaptive capacity over a given period is difficult, (2) even the best modeler cannot forecast the future, (3) human memory is often unreliable in accounting for changes in near or long horizons, and (4) mapping dimensions of social change and ecological change do not appear to be reconcilable at first glance. The first problem has usually been dealt with by measuring vulnerability. These vulnerabilities often include limited access to natural resources, markets, and credit; food and water insecurity; weak institutions and governance (Füssel and Klein, 2006). Furthermore, establishing baseline conditions for the climate-vulnerable should take into account variable cultural, political, economic, and biophysical geographies. This has been a particular critique of anthropologists and geographers (e.g., Wisner, 2005; Crate and Nuttall, 2009).

Models and model outputs have become emblematic of climate change research, from the most sophisticated ENSO models to the simplest logistic regression of survey data. Models, as Parker (2010) and Hulme (2012) have both argued, become the figurehead of climate and global environmental change research because of their ability to represent high degrees of complexity. Despite all the underlying assumptions, researchers use models as a way to understand what future environmental conditions may hold for society. An epistemological emphasis on models may lead to the neglect of other forms of inquiry, such as personal narratives (Roncoli, Crane, and Orlove, 2009). Nevertheless, incorporating both a quantitative and qualitative interpretation of the future for exploring social dimensions of climate change is not common (Alcamo, 2 0 08).

Human memory is fallible, and recounting what might at first appear to be basic facts can be elusive for the researcher (Salamone, 1977; Bernard et al., 1984). This is of course a deficiency in interview and survey data that is best triangulated upon with observational and archival data, and in the best-case scenario experimental sources. Acquiring any or all of these sources in addition to what is interviewed or surveyed, however, is generally not so simple, especially in often difficult field conditions in the rural developing world. Not unrelated is the

difficulty inherent in mapping social time over ecological time, or vice-versa, a project that has received attention in work by interdisciplinary research teams, and has proven difficult to derive given the internal logics and sources for uncertainty from which each is composed (Walker et al., 2006; Wood, 2008).

The following research question motivates this research: *Do households and communities in the Eastern Cape demonstrate adaptive capacity to climate change across temporal measures of past, present, and future?*

Life histories were conducted with elderly people in certain households in all four villages to acquire information about past events and adaptive strategies. The respondents had all spent the majority of their lives in the communities in question. The present was scrutinized through livelihood surveys, whole and personal network surveys, and network ethnographies. For the future, focus groups and fuzzy cognitive maps (FCM) were utilized with participants in a workshop setting (see Figure 1).

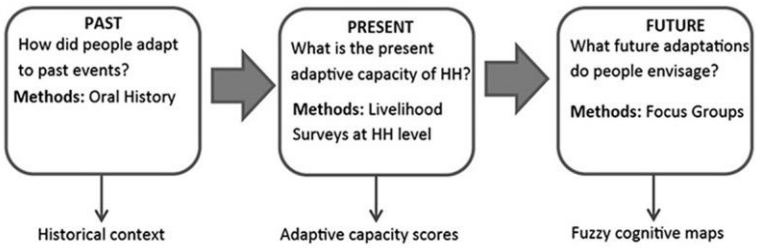

Figure 1. Questions, methods and outputs in the timewards approach (3 steps).

Adaptive capacity is not a static outcome, even if its addition to a statistical model gives that impression. Households with high livelihood diversity and household health are referred to here as having high adaptive capacity for statistical purposes. Again, emphasis is on the household's potential as derived from the definition of adaptive capacity above. Households with adaptive capacity should demonstrate both greater livelihood diversity and household health. Additionally, natural resource reliance has been proposed as a possible indicator of adaptive capacity (Cousins & Kepe, 2004; Thomas & Twyman, 2005; Turner et al., 2007), but it as an additional dimension of life in these rural contexts, not as a substitute. The importance of understanding time was explained by Wood (2008):

> Temporal factors are of paramount importance because the degree to which society and nature operate in consonance or dissonance profoundly influences the health of the natural environment, the structure of the social system and, hence, the prospects of sustainable development…the sensitivity to temporality is commonly blunted in the design and execution of interdisciplinary social- ecological research, the precise context in which temporal co-ordination is imperative.

Callender (2008) refers to this as the dilemma of a "tenseless" view of time that is common in most scientific research. "Tensers" view time as being dynamic and classifiable in the past, present, and future. Any effort to describe human and natural systems, and especially those concentrating on issues of sustainability, take a position on temporality, favoring the

tensers (Baptista, 2012). But research design, particularly through hypothesis testing, is tenseless. In addition, individual disciplines each have their own special approaches to temporality (Wood, 2005). Geology is premised on expanding an understanding of the past beyond what humans have contemplated (McPhee, 1982). Cellular biologists who study yeast growth focus on time scales measured in seconds (or less) (Morgan, 2007). Economists study cycles of flux that vary widely but are intractable to the human imagination (Vickers, 1994). Social-ecological research singularly straddles the divide, which complicates how to view the research subject and assess perturbations, including climate change.

Social-ecological research is not only constrained by the differing temporalities of discipline, but also by the temporalities of field research itself (Faubion and Marcus, 2 0 09). The time the researcher is actually conducting fieldwork presents an often divergent time horizon (Alcamo, 2008). Most field research with this in mind is conducted in months, and only sometimes years.

Study area

Willowvale: Muncu and Tokwe

Muncu and Tokwe are two representative amaXhosa villages in the former South African homeland of the Transkei (Figure 2). Like many rural parts of the former Transkei, they are uniformly inhabited by the amaXhosa. Both villages are located in the Mbashe local municipality which lies in the Willowvale district and are contained within the Maputuland-Pondoland-Albany subtropical thicket biome, an internationally recognized biodiversity hotspot. South African conservationists have identified this biome as key both in the provision of ecosystem services and for the mitigation of the effects of climate change (Forest et al., 2007).

The residents of the Muncu and Tokwe villages live under a traditional governance system composed of headmen and chiefs of various ranks. The two villages have different headmen but fall under the same *inkosana*, or paramount chief. Land tenure is customary, and is largely at the discretion of the chief.

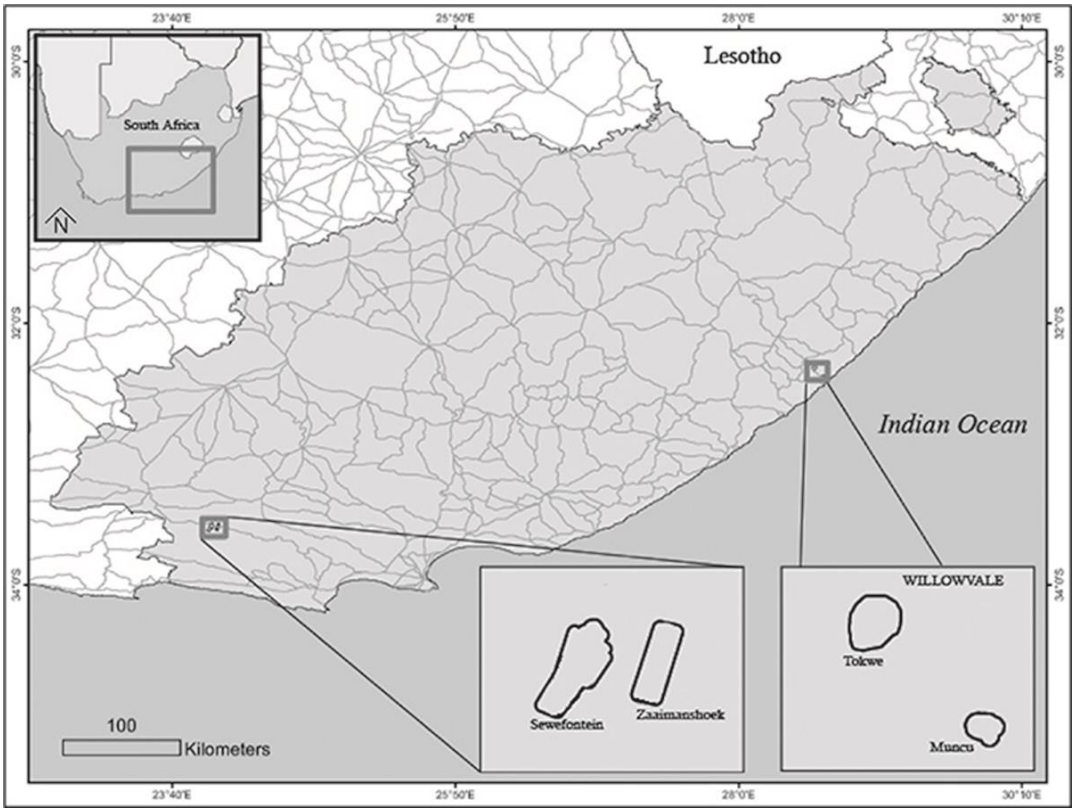

Figure 2. A map of the study areas in the Eastern Cape of South Africa. Data sources include ESRI and the Departments of Geography and Environmental Science at Rhodes University.

The Baviaanskloof: Sewefontein and Zaaimanshoek

The Baviaanskloof is both the name of an administrative local municipality and physical geographic region. Sewefontein, a land reform farm, and Zaaimanshoek, a village, lie in the center of a culturally and ecologically rich UNESCO Heritage Mega-reserve of some 500,000 hectares. Both villages are made up of colored (a South African term for persons of mixed-race, but in this case predominantly Khoisan heritage [Adhikari, 2009]) residents, as are the majority of the valley's population. Most land in the area is owned privately by white commercial farmers (Crane, 2006). The colored population is predominantly employed in seasonal farm work (Cocks et al., 2007).

The area sits at the intersection of seven floristic biomes (Van Eck et al. 2010), most prominently the Cape Floristic Region subtropical thicket biome. Like the Willowvale villages, it too occupies the subtropical thicket biome. In recent years residents of the Baviaanskloof Valley, urged by conservation scientists, and the South African government, have attempted large-scale ecological and potentially geomorphological restoration focused on the removal of alien invasive plant species and the reshaping of riparian systems (Hawn, 2005; Bobbins, 2012). Many of the white farms have also become centerpieces of an ecotourism effort for the valley as a whole; majority colored population are only partially employed in these ventures.

Sewefontein and Zaaimanshoek have differing governance forms, with Sewefontein functioning as a land redistribution farm of over twenty-five families with a largely male farm committee administration, and Zaaimanshoek with forty-two households, under the dominion of the United Congregationalist Church.

The Baviaanskloof communities are also rural, but only Sewefontein demonstrates any agricultural output given its status as a redistribution farm. Three percent of the households in both communities cultivate a field, and forty-five percent have some livestock. Most households have a garden where they grow some food and medicine crops. As with Willowvale, deagrarianization may help to explain the low level of cultivation, but in the Baviaanskloof there is also less available land to cultivate (Crane, 2006). Sewefontein and Zaaimanshoek are more than 75km away from any markets or other urbanized areas, also via a very rugged road. In both communities water is pumped in and electricity and telephone access is periodically available.

Methodology

The "temporal extent" includes periods recollected in oral histories from the, 1930's to predictions for the future in, 2030, but the "temporal grain" (Wood, 2008)—that is, when these data were collected—occurred between August, 2011 and July, 2012. Adaptive capacity, and the measurements drawn upon are livelihood diversity and household health.

No single village or assemblage of households was chosen on the basis of their livelihood diversity or household health—all explored here—and therefore these features were randomly, not purposefully, sampled for. As explained in the next section, they are representative of social-ecological trends transpiring across the region.

The definition of a household adopted by the South African census bureau, Statistics SA (2012) is a contested (Bender, 1967; Keilman, 1995). Statistics SA (2012) defines a household as a place where a person or persons eat together and share resources; and where they normally reside four nights a week at the specific visiting point. The census in the four villages showed that the number of households ranged from twenty-five to forty-two.

Understanding current adaptive capacity

The temporal frame of the present is used to assess results from the past and to establish connectivity with subsequent frames. Livelihood surveys were conducted in every household with an adult residing in the household for more than a year (N= 132). Adult respondents were randomized in terms of who was spoken to in order to reduce the possibility of bias. The survey itself is loosely based upon similar livelihood surveys used elsewhere in the Eastern Cape. The survey measures financial, natural, social, human, and physical capitals, five assets identified in the sustainable livelihoods framework (Scoones, 1998), as well as respondents' perceptions of environmental change. Livelihood diversity includes categorical and continuous responses from the survey data, including financial income, employment status, agrarian activities, non-timber forest product (NTFP) collection, and receipt of social grant in an effort to capture the "hidden harvest" present in diverse rural livelihoods.

Household health is a quantification of mortality and moribundity. The items include the number of deaths and illnesses in the last year, current prevalence of disease in the household, and the effects of disease on the household. The two scores of livelihood diversity and household health are aggregated to give a single measurement of adaptive capacity. Natural resource reliance was measured as a composite of natural resources utilized by the household. These include items related to timber products and NTFPs, water, fields, home gardens, and livestock.

Understanding past adaptive capacity

Oral history interviews were conducted to assess past forms of adaptive capacity. These were conducted with the elderly (or those of pensionable age; over 60) in both the Baviaanskloof

(n=13) and Willowvale (n=14) communities as a primary means of acquiring information about past events. Their responses refer to changes in the communities. Each interview transcript was coded until nothing novel was produced. The unit of coding was an interviewee's 'beat,' or related thought, rather than a sentence or paragraph, a common practice in qualitative content analysis methodologies (Schreier, 2012). Themes of adaptive capacity included "climatic change," "agrarian strategies in transition," "alternative agricultural strategies," or "innovative uses of natural resources." The codes of "extreme events" and "current resource reliance" were coded for context. They, too, emerged as a result of data saturation. Figure 3 illustrates the coding procedure.

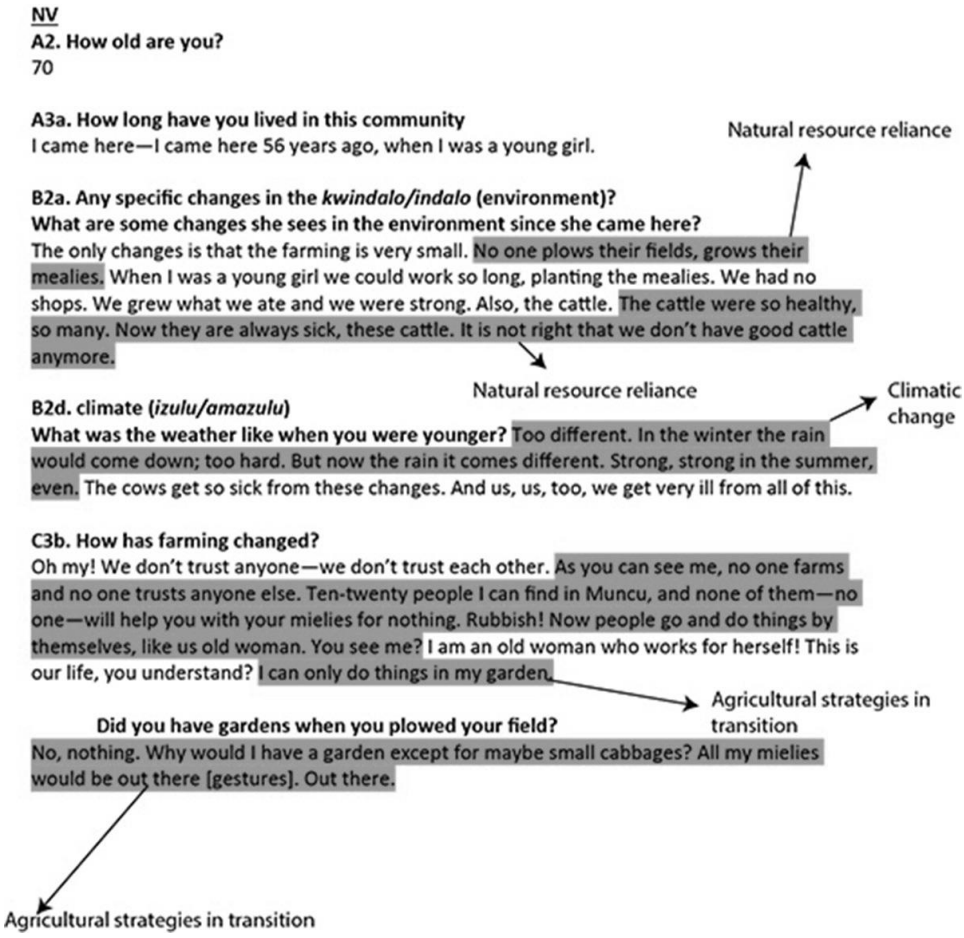

Figure 3. Example oral history transcript and the codes used in analysis.

The oral histories contextualize a historic understanding or interpretation of adaptive capacity. These are emphasized by the themes that emerged from the coding process. Analysis to this end consisted of searching for the above codes using computer assisted qualitative data analysis (CAQDA) software and observer impression. The example above illustrates how the codes fit with the coding scheme, and thus a categorization of adaptive capacity. "No one plows their field, grows their mealies," for instance, receives a natural resource reliance code. The excerpts are divided into quartiles based on their measurements of both livelihood diversity and household health. Resampling allows for consistent matching for households of low, medium, and high score values and then coded results after the fact.

Understanding future adaptive capacity

For this frame participatory rural appraisal, focus groups, and fuzzy cognitive maps (FCM) were used, a scenario planning methodology composed of Markov chain simulations (Kosko, 1986). The fundamental question in this temporal frame is what future adaptations do people living in the four study villages envisage given a changing climate. These workshops were arranged over several days in both Willowvale and the Baviaanskloof districts. Using a subsample of households based on their structural position in a social network, eighteen household representatives from Willowvale (Tokwe=nine, Muncu=nine), and twenty-one in the Baviaanskloof (Zaaimanshoek=thirteen, Sewefontein=eight) were identified. Each workshop relied heavily on PRA strategies in an effort to derive future scenarios, and therefore forms, of adaptive capacity. FCM were derived from several workshops where drivers and outcomes were simulated.

FCMs have been used in both social science research and management settings (Hobbs, 2002), and operate on the principle of fuzzy logic. This is probabilistic and deals with phenomena that are approximate, not fixed (Kosko, 1986).

Individual groups were identified to report on human-environmental conditions in their community. Future changes in temperature and rainfall (projective) were identified, alongside sources of adaptation to further environmental change (exploratory), and exactly what adaptive capacity means to the respondents themselves (environmental and policy-oriented). Drivers and other responses demonstrating adaptation and coping are present. Adaptation is the more permanent ability to adjust to one's surrounding conditions, while coping is temporary. Values are assigned to drivers in terms of ordinal importance, which were subsequently categorized using pentavalent logic (-1, -.5, 0, .5, or 1). Each map was peer reviewed by the participants during the workshop. The map, complete with the values assigned to the drivers, was entered as a matrix into a program called FCMapper (Bachhofer and Wildenberg, 2009).

Focus groups in these workshops allow for the acquisition of perceptions of adaptive capacity that emphasize continuity with those found in the oral histories. Focus group responses for qualitative analysis are based on quartile-ranked measurements of livelihood diversity and household health. Both qualitative responses and quantitative position are therefore depicted. Data is divided into quartiles because they are the most efficient mean estimators for rank sampled data (Muttlak, 2003), and then explored the same codes in the FCMs in a more open-ended format. Subsequently, transcribed data was analyzed using CAQDA, as well as on notes obtained from the workshops. The future themes align but do not overlap with those of the past and emphasize "climate change," "agrarian strategies in transition," "alternative agricultural strategies," "natural resource reliance," and "new natural resource use and innovation." FCMapper was utilized on FCM's and CAQDA software for the coding of focus groups.

Results and discussion

Results from the present

Figs. 4 illustrate differences in adaptive capacity for the four study communities. These differ in some respects from reports highlighting the many ways in which households utilize natural resources and diversify their livelihood strategies. Figure 4 illustrates how Muncu and Zaaimanshoek emerge as having the highest median adaptive capacity score. Tokwe and Sewefontein are the lowest. Interestingly, their numbers align such that one dyad of Baviaanskloof/Willowvale villages represents the lower half of the distribution and the other the

upper half. Also of note is the central tendency and dispersion of the adaptive capacity scores in these communities. There are a few outlier households in Zaaimanshoek that move its distribution to the right, but there are actually a greater number of households in Muncu (Figure 5) occupying the third and fourth quartiles for the adaptive capacity score.

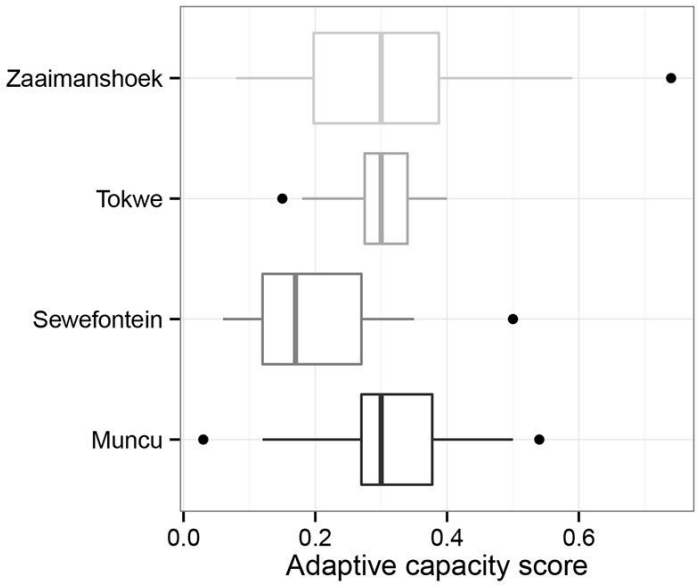

Figure 4. Boxplot of the adaptive capacity scores for the study area.

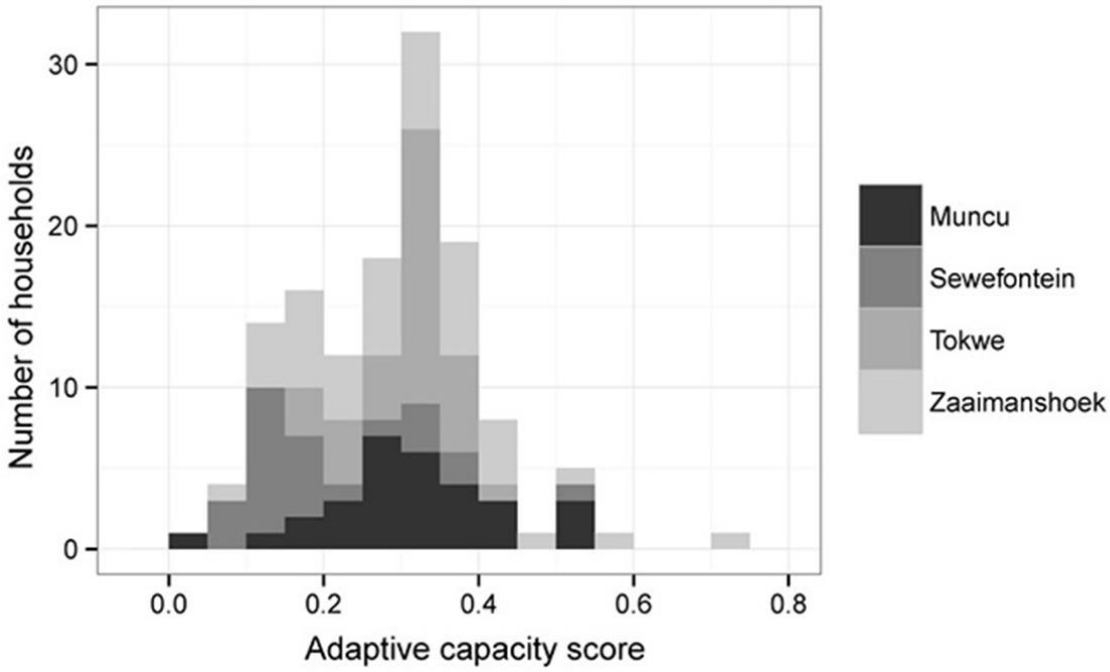

Figure 5. Household-level adaptive capacity considering household size.

As noted, the literature—especially that pertaining to southern Africa--has highlighted all

the constituent parts of the composite measurements used to create the adaptive capacity score. As Table 1 demonstrates, there is variability in the outputs and Zaaimanshoek and Sewefontein emerge with the highest livelihood diversity scores, but the lowest household health measurements (of both morbidity and moribundity. All of these combine to form the score referred to as adaptive capacity.

Table 1. Measurements of livelihood diversity and household health in the study area.

Study area	Community	Livelihood diversity			Household health			Adaptive capacity		
		Mean	Median	Standard deviation	Mean	Median	Standard deviation	Mean	Median	Standard deviation
Baviaanskloof	**Zaaimanshoek**	0.2	0.16	0.18	0.41	0.38	0.17	0.30	0.30	0.13
	Sewefontein	0.16	0.15	0.11	0.21	0.17	0.18	0.19	0.17	0.11
Willowvale	**Tokwe**	0.08	0.07	0.06	0.51	0.52	0.12	0.29	0.30	0.06
	Muncu	0.1	0.08	0.09	0.51	0.41	0.2	0.31	0.30	0.11

There is a statistical difference in the household health scores for these two communities ($P<.05$), indicating that households in Sewefontein return significantly lower reports on this measure of adaptive capacity relative to Zaaimanshoek. In this way, Sewefontein demonstrates less adaptive capacity on this measure. Additionally, the differences in livelihood diversity is significantly different between villages, with the exception of household health, in which case the household health scores for each set of community are not statistically different (at $P=.057$).

Discussing the present

Adaptive capacity is not uniform—not even in villages very close to each other and of similar composition. Of note, the Baviaanskloof community of Zaaimanshoek has far more in common with measurements of adaptive capacity with the Willowvale communities than it does with Sewefontein (with the exception of dispersion—Tokwe has the lowest standard deviation in this regard). Relatedly, Muncu has the highest mean adaptive capacity score, but the medians of its, Tokwe's, and Zaaimanshoek's scores are identical. Broken down, Sewefontein is lowest on the overall adaptive capacity measurement and lower still in a measurement of household health. The central tendency of Muncu in all measurements might lead to the conclusion that it has the most adaptive capacity of all, but that would be to overlook some of the other distinctions, including Zaaimanshoek's high livelihood diversity reliance.

Zaaimanshoek's household health scores are revealing: the community is home to a clinic, visited by nurses every few weeks during the best of times. That visit can assist, especially in a locale where tuberculosis is rampant (personal communication with health clinic, 2012). Take Sewefontein, where tuberculosis is noted in the interview data, but so is the dysfunctional nature of the farm. Sewefontein's households receive fewer forms of social grants than Zaaimanshoek, mostly because they have fewer children and elderly; this too could reduce adaptive capacity. Number of households may be a factor, but the fact that Sewefontein appears so low on the overall score is likely not an effect of this.

The high AC scores in the Willowvale villages and Zaaimanshoek could be due to two features: 1) off-farm employment opportunities and 2) similar health profiles. In Muncu, households are more able to seek employment in nearby tourist enterprises, but this employment option is unavailable to residents of Tokwe. On the other hand, Tokwe is closer to the largest urban center and more accessible via the main road, which may counter the lack of tourist employment. The health profiles are largely the same for the two Willowvale villages, however there were fewer reported deaths and chronic illnesses in Muncu, likely explaining the difference in the median score. As for the individual cases that situate Tokwe's overall distribution, this may be explained by a more cohesive kinship pattern in the village: there are more direct relatives present than in Muncu. Most of the community is directly related to both the area's headman and paramount chief.

Results from the past

Transcripts from the oral histories were closely assessed for content, and the selection procedures of ranking the households and then coding responses allowed for a representative sample. A summary of the coded responses is shown in Table 2. Within the oral histories, the theme of "agricultural strategies in transition" was the most oft-cited code across all oral histories in both communities (on average more than, 194 references were made), and a "changing climate" was second (an average of 92.6 references).

Table 2. Results from coding of oral history responses.

Oral history codes	Sewefontein		Zaaimanshoek		Tokwe		Muncu	
	% of transcript coded as	Count	% of transcript coded as	Count	% of transcript coded as	Count	% of transcript coded as	Count
Changing climate	3.8%	3.2	9.1%	13.5	4.0%	4.0	2.1%	4.8
Extreme events	0.0%	0.0	2.5%	1.0	0.0%	0.0	0.0%	0.0
Alternative agricultural strategies	1.6%	1.8	2.8%	2.0	0.0%	0.0	2.8%	1.0
New resource innovations	0.0%	0.0	2.9%	2.0	0.9%	1.0	1.2%	1.0
Natural resource reliance	4.2%	3.8	2.4%	4.0	2.9%	2.20	2.9%	3.0
Agricultural strategies in transition	8.3%	11.8	4.5%	7.7	6.2%	9.2	3.8%	6.8

Agricultural strategies in transition. Examples of agricultural strategies in transition can be found in household cases from elderly household respondents in all four communities. The majority of these appear to support the contention that strategies have changed. S23, representing a household ranking on the lowest quartile for livelihood diversity and household health, notes that:

> Now it rains but [it] doesn't come for very long…[E]nd of July then you have to plant things. If we have a thunderstorm now you must put a few crops in the soil quick. But if the thunderstorm rains, your crops will still be dry even today. The cropping time used to be in August. If you plant in August you get nothing! You have to plant in September—for anything: apples, pumpkin, mielies (maize), you will waste your energy for that.

Similarly, Z34, who represents the highest quartile for livelihood diversity and household health, observes that:

> We don't have normal weather—my hands are turning [to] ice as I smoke, you see? Farming hasn't changed a hell of a lot since many years. The big thing is the machines. And they have stronger chemicals, too…We were never supposed to have our own animals, and since the white farmers won't ever let us. The weather doesn't change this.

Both of these responses emphasize how agricultural strategies have changed in response to perceived variations in the climate. They emphasize features of climate change and variability lodged in the recorded data for South Africa (Low, 2005). The last two excerpts point to shifting agrarian patterns for households in the study area, as exemplified by Muncu household ND2, who points to decision-making on the perceived changes in the prioritization of labor and activities spent in the agricultural sector:

> In the old days we would plow, but now we don't have any reason to plow. We have so many fancy things from the shops. There is no one who wishes to plow. We have become too lazy. We are not working hard—not like when I was young.

Another household in the Willowvale area, Tokwe household WB (who represents a different quartile for each score) highlights changes as well, but instead focuses on what he perceives to be the role of government assistance in aiding or hindering efforts:

> How can we plow? There is no reason to plow. We have no machines…we have no one to pay to help us…[H]ow can we go to the veld and collect anything? For children, only. We don't have any time, no money. If the government would give us something, we would be the best village in South Africa. But they give nothing to us.

Changing climate. The changing climate conditions experienced by households differ. NM4, a household in Tokwe occupying the third quartile for livelihood diversity and household health has the following to say:

> It was always quiet weather. These days there are just too many problems to deal with, too many things that make problems for us. A hard life. And rain is just a small one…In the olden days there were storms but now they are over. We get some rain, but not too

much—never in the right time.

NG, a household from relatively nearby Willowvale, speaks of variability. Her household occupies a different quartile for livelihood diversity and for household health: "The rain is falling too fast and too hard. But it comes in big bunches. Storming, nothing, storming, nothing. This is not the right pattern for the rain…from when I was very young."

A household in Zaaimanshoek (Z39) occupying the lowest quartiles for livelihood diversity and household health provides a different reflection upon climatic conditions than the Willowvale interviewees: "It has gotten drier here and it has made things somewhat harder. The soil has gotten much worse…the river! The river would storm up and then get dry; storm up, get dry…Not any more."

Upon further inspection, the climate change references across all four offer widely varying interpretations for how climate is changing. However their responses do not differ tremendously from another household with both the highest quartile of livelihood diversity and household health in Z39. The other codes do not appear throughout the interviews.

Discussing the past

Overall, it appears the answer to whether households and communities in the Eastern Cape demonstrate adaptive capacity to climate change, as measured by their livelihood strategies, and life histories is conservatively affirmative. The extent to which a timewards approach can solve the riddle of temporal inadequacies in measuring the potentialities latent in adaptive capacity is difficult to ascertain. The reader, the authors, and those with whom we worked occupy temporal frames that have already changed from the first to the last word of this sentence, if however slightly. Results here are supportive, however. The oral histories reveal a range of perspectives on themes employed under the coding for contextual, qualitative forms of adaptive capacity, to bolster the quantification of the adaptive capacity scores. Huge variability between households does not manifest in narrative form. The initial oral history interviews are phenomenological: stressing everyday life and its associated states of consciousness (Kirby, 2008).

The oral histories, keyed broadly as the "past," give insight into a number of coded forms of adaptive capacity. Despite understandable individual variation, a hallmark of phenomenological studies, themes of climate change and changing agrarian strategies in transition are discernible. Measurements of present adaptive capacity may have weak relationships with conceptualizations of the past. There were some exceptions, and those households like Z34 (highest quartile) and Z39 (lowest quartile) seem to show some correspondence between present-day adaptive capacity scores and discussions of past forms. More varied responses depicting a changing climate are evident in the Willowvale sites; more consistent themes can be seen in the Baviaanskloof sites. The Baviaanskloof responses uniformly refer to hotter and drier conditions. One aspect highlighted in both groups is the variability in climate conditions, which perhaps could also help explain the Willowvale responses.

Results from the future

FCM's and focus groups produced factors that did not arise in other methods related to adaptive capacity. FCM simulations were run until they converged at, 20 iterations. This small

number of iterations, and the relatively small number of factors introduced, explains why some of the factors actually appear to be equal—when in fact in a more complex model, greater variation might have emerged between factors. FCM outputs detect varying interactive factors that might not normally be detected using other methodologies. A diagram of the FCM for Zaaimanshoek is shown in Figure 6. Drivers, (push factors) such as "UCC church restrictions" in Zaaimanshoek and "poor roads" in Muncu were assessed together with the outcomes or outcome states (pull factors), such as "building own shops" in Sewefontein and "police stations" in Tokwe.

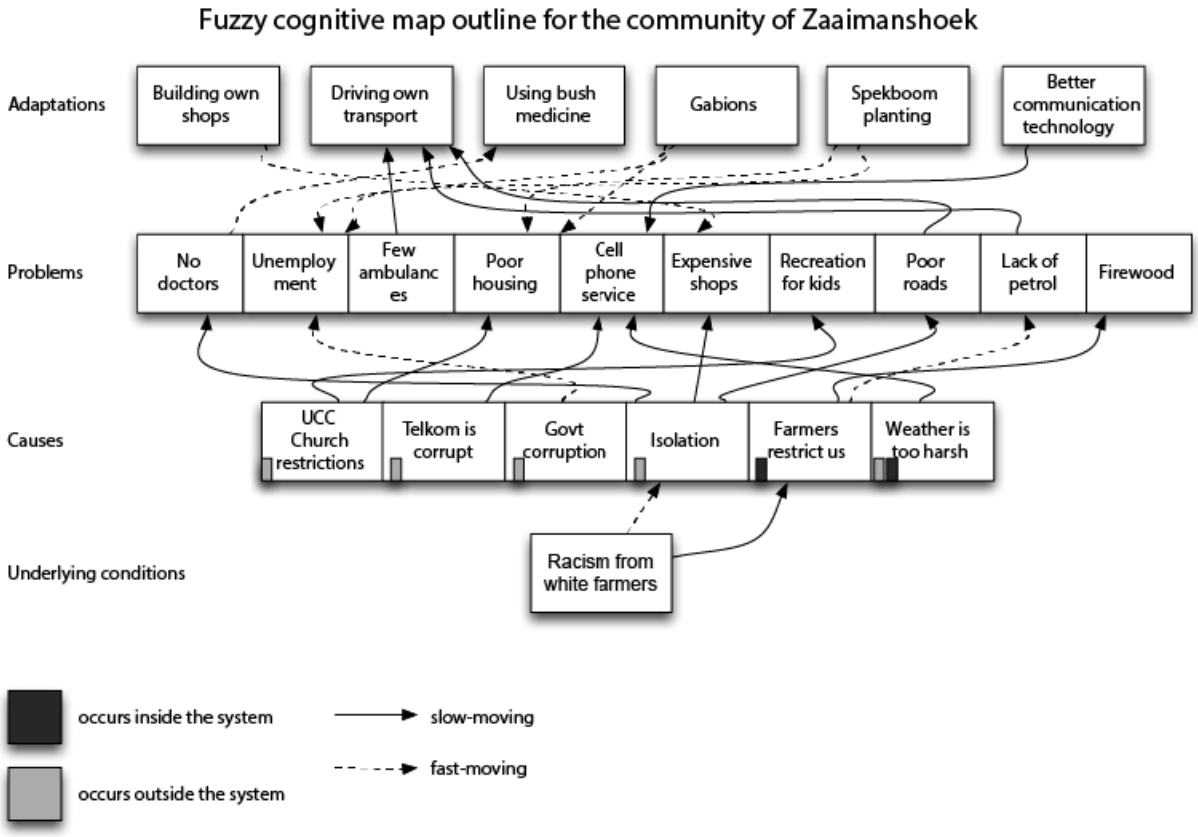

Figure 6. A template of the FCM for the community of Zaaimanshoek before the model was run.

Most of the direct agricultural, natural resource, or climate change-related factors converge after only a few iterations in the simulation, indicating that they are not generally dynamic. Therefore patterns of adaptive capacity, as defined earlier, do not have direct analogues in this model. There are neither numerous nor pronounced effects in the interaction between these drivers and their expected outcomes. Exceptions include "application to farm sponsors" in Sewefontein (three iterations), and "drought" in Tokwe (three iterations). These appear to be very interactive with parts of the FCM. And while this study surveys climate change adaptation, factors such as "rain" in Towke (1) and "not enough rain" in Muncu (1), these factors largely do not appear to be interactive with the system as currently simulated. In essence, this model does not reinforce the same themes from the previous temporal frames.

Focus group responses. Variability in the focus groups is most notable in the "community change" and "changing climate" codes. Interestingly, the "agricultural strategies in transition" code was the least resonant—this code did not surface to the same degree as in the oral histories. The households in Willowvale who occupied a very central position in their social networks arose as being the subsample most eager to discuss this theme, which recurs from the oral history data.

Focus groups respondents were asked to express how they imagined future conditions in their respective community to be. The prompt in this section of the focus group was to think of "many years from now," and if that did not appear to elicit a response the year, 2030 was referenced. The following excerpts are from a subsample group, emphasizing what some respondents thought would be examples of adaptation versus coping. These two indicate possible future forms for adaptive capacity: "Our farm will function without any help; we will be a real farm for a change. You will see that all our roads will be very well constructed and we will not have any worries about transportation" (Sewefontein: S7, S19). "Finally doctors will be near us, near our homes. This will be the first time this has happened to us, and the first time they begun to care about the colored people" (Zaaimanshoek: Z12, Z14, Z2, Z33, Z3).

However the following households from the Willowvale area are less optimistic, and fitting with the study subject, in possession of lower adaptive capacity: "In the future, there will be no money here. No one will ask money from someone else and everyone will be poorer than dirt" (Muncu: GM, VT, ND4). "We will not have good mieles [maize] in the future with how we do things. Those mielies will die because we have no help…but we will have electricity, which will light up the sky" (Tokwe: AB, CM, MM, NM).

Many of the responses do not reflect the strengths identified in measurements of adaptive capacity, and perhaps not even in traditional conceptualizations of environmental change, but these were conceptualized as the real forms of adaptive capacity experienced. These responses are nonetheless reflective of some community-level understanding of what the (conditional) future might hold. Each focus group was referenced, those particularly related to climate change and disease, although they were not always evocative. The excerpts from Muncu and Zaaimanshoek provide exceptions: Muncu's respondents reference the lack of income-producing opportunities in the community while Zaaimanshoek's reference the healthcare dilemma there (Zaaimanshoek is home to a clinic visited by a nurse once a week or less).

The "changing climate" theme, categorized under the rubric of adaptive capacity as noted above, also demonstrates noteworthy themes--depicted here with the isolate subsamples. There is no discernible text themed as "changing climate" in any of Tokwe's responses:

> The rain is much less now every year. Sometimes it is too much less, and it gives us many stresses. The government should give us water pumps if they wish for us to survive—this is the solution (Muncu: MD, NG2, DB)
>
> We had big floods in the, 1990's. Storms were many, many. Now it is not right. You don't know when it is supposed to be the hot or cold weather; winter or summer, we cannot tell you anymore. We don't know what anything will be like in the future (Sewefontein: S4, S12, S17).
>
> We've had many worse storms in the past. The storms are not raining like we

> remember. The rain comes, but it is never when you would expect it anymore. And the winters? Too cold for us to even believe it. In the future we can only expect God to be merciful (Zaaimanshoek: Z15, Z22, Z31, Z30).

These series of responses point to varying interpretations of climatic change and variability in the study area and a not always clear idea (with the exception of Muncu in these excerpts) of what this variability will manifest as in the future. Accounts of these phenomena are not uniform, however: some brokering subsamples in either group did not mention this theme in any one of their responses.

Discussing the future

The bulk of this article focuses on the role of adaptive capacity, but the measurements of the future as seen through the fuzzy cognitive maps reveal little support for measures observed within the other two time frames. They represent an approach to gauging whether forms of future adaptive capacity might exist at the community level in relation to climate change and disease, but if anything they illustrate a community-wide perception of future circumstances wholly separate from the answers garnered in other methodologies (e.g., interviews and surveys). In both cases the outputs demonstrate difficulties in connecting the research objective with the lived experiences and local understanding of adaptive capacity by many household members. In both the focus groups and the FCMs it is clear that communities are still very much affected by the vestiges of rural land policies dating back to apartheid. In the FCMs many of the human-environmental components represent the preponderance of themes of adaptive capacity. They also do not appear to play a dynamic role in the scenarios. This could be a reflection that communities do not view climate, livelihood diversity, and the health of their household, as undergoing flux—or that change is already evident amongst these components and will not be dependent upon further shifts in the other aspects of the scenario.

Focus group responses were divided initially amongst subsamples, yet those divisions did not appear to have a meaningful effect on the qualitative responses. One thematic code that addresses “new realities” conceptualizes the environment as being a function of both household economics and public health. It is notable that community responses are not uniformly utopian; in keeping with principles of resilience and adaptation, many community members recognized that their current situations could, in fact, be less ideal in the foreseeable future.

Conclusions

Clearly, adaptive capacity is multifarious, and the tendency is to include all such outcomes has been a nagging problem for the concept. But highlighting the limits and clear definitions in demarcations of potentiality and ability, and foremost of time, allows for a clearer analysis. These data indicate there is decreasing adaptive capacity in the study area. This is in spite of the increasing development and urbanization patterns in the rural Eastern Cape. The past and present frames indicate low levels in spite of scores emphasizing qualitative responses from the past. The future, highlighted by FCM’s and focus groups, is not nearly so definite, although focus group responses parallel those from oral histories in emphasizing low adaptive capacity. Simulated models of the future, however, indicate that community-level perceptions of the importance or relevance to the future as defined through measurements of adaptive capacity are not what one might expect based on other methods.

Presented here are reliable, internally valid measurements of adaptive capacity, with emic

perspectives contextualized from the past and future. These are valuable to studies in resilience and community based adaptation, as both bodies of literature are as concerned with how to locate the vulnerable (people or ecosystems) as they are with measuring it. Temporal diversity is rarely discussed, and thus barely understood, when discussing adaptive capacity at the individual level, let alone at larger units of analyses and scale. As with any work that seeks to explore the social dimensions of climate change, three temporal frames reveals only a limited aperture.

The adaptive capacity scores reveal great variability: intra-community phenomena is more diverse than suspected and also shows the importance, and weight, of individual households. Tellingly there are cases where superficially similar communities can be bifurcated along the lines of the land-based and health measures used. This points to the disconnect using socioeconomic measures of complexity exclusively.

Oral history responses in this study reflect the contentious histories of both colored agricultural regions and the former Bantustans of South Africa, but rarely did the interviews reveal the country's political history other than through subtle elicitations of dates. More often than note, mundane features of environmental history were explored, with continuous interviewer probing on questions related to changing conditions and with an eye to the eventual survey used to craft an understanding of adaptive capacity. References to a changing climate and changing agricultural strategies occurred in virtually all the interviews. Changing uses of natural resources were less resounding, which indicates either the elderly's limited present-day exposure to the harvesting of firewood and NTFPs Precisely because many of the respondents refer to changing agricultural strategies (although they often bemoan the shifts themselves), an underlying interpretation of adaptive capacity surfaces in most interviews—and it is lower now than in previous times. The socio-ecological system of these two communities is complex. Respondents clearly concur that the rural identity of the Eastern Cape is not an agrarian one, no matter the strong cultural attachment to the surrounding natural environment. But it is possible that the identity of the household has changed as rural villages in the province have become more rigid and resistant in the face of ongoing uncertainties.

Through an analysis of the future effective envisioning is possible at the community level, but as is evident in the examples demonstrated above, a wider approach should be utilized. These are the responses of household representatives in a group forum, not a council or other form of democratic governance structure that might lay greater claim to the community mantle. What grounds this argument is the evidence that both these techniques neither revealed utopian nor dystopian visions for present social-ecological systems, including climate conditions and water availability. Indeed, many of the comments and scenarios reflected needs, including a lack of natural and other resources. If, as many in the workshops forecast, these communities "become modern" (Geschiere, Meyers, and Pels, 2008), yet still maintain at least heritage ties to agrarian livelihoods their stores for adaptive capacity as defined here could be ensured. Their fundamental identity could also undergo transformation, as in the example from Tokwe's workshops in reference to animals, and Sewefontein's references to the longevity of their reform farm. Arguably their household sources for adaptive capacity already have.

Adaptive capacity, given its emphasis on potential, is also imbedded in learning and innovation. From a preliminary reading, household identity has changed. This is especially the case from a basic needs or classical development perspective, taking into account the social grants system in South Africa. From a livelihoods perspective, this may be less the case. Decreasing diversity of livelihood strategies may result in a decrease in adaptive capacity. Another aspect of learning is the loss of traditional ecological knowledge (TEK) due to

diminishing interaction with the land. While TEK can be supplanted with knowledge of the function of markets and capital, this could have compounding effects on a household's use of natural resources. Finally, HIV/AIDS and tuberculosis, diseases that mark the daily lived experiences of Willowvale and the Baviaanskloof, have tremendous consequences for a household, and this may lead to a loss of risk-taking or innovation.

References

Adger, W. Neil, Suraje Dessai, Marisa Goulden, Mike Hulme, Irene Lorenzoni, Donald R. Nelson, Lars Otto Naess, Johanna Wolf, and Anita Wreford. "Are There Social Limits to Adaptation to Climate Change?" *Climatic Change* 93, no. 3 (2009): 335–54.

Adger, W. N., T. P. Hughes, C. Folke, S. R. Carpenter, and J. Rockström. "Social-Ecological Resilience to Coastal Disasters." *Science* 309, no. 5737 (2005): 1036–39.

Adhikari, M. *Burdened by Race: Coloured Identities in Southern Africa*. Cape Town, South Africa: UCT Press, 2009.

Alcamo, J. *Environmental Futures: The Practice of Environmental Scenario Analysis*. Amsterdam, The Netherlands: Elsevier Science, 2008.

Bachhofer, Michael, and Martin Wildenberg. *FCMapper* (version 1.0). Excel, English. Vienna, Austria: FCMappers, 2009.

Baptista, João Afonso. "The Ideology of Sustainability and the Globalization of a Future." *Time & Society*, 2012. doi:10.1177/0961463X11431651.

Bender, Donald R. "A Refinement of the Concept of Household: Families, Co-residence, and Domestic Functions." *American Anthropologist* 69, no. 5 (1967): 493–504.

Bernard, H. Russell, Peter Killworth, David Kronenfeld, and Lee Sailer. "The Problem of Informant Accuracy: The Validity of Retrospective Data." *Annual Review of Anthropology*, 1984, 495–517.

Bobbins, Kerry Leigh. "Developing a Form-Process Framework to Describe the Functioning of Semi-Arid Alluvial Fans in the Baviaanskloof Valley, South Africa." Rhodes University, 2012.

Bryceson, Deborah Fahy. "Deagrarianization and Rural Employment in Sub-Saharan Africa: A Sectoral Perspective." *World Development* 24, no. 1 (1996): 97–111.

Bunch, M. J. "Promoting Health and Well-Being by Managing for Social–ecological Resilience: The Potential of Integrating Ecohealth and Water Resources Management Approaches." *Ecology and Society* 16, no. 1 (2011).

Callender, Craig. "The Common Now." *Philosophical Issues* 18, no. 1 (2008): 339–61.

Campbell, John R., Michael Goldsmith, and Kanyathu Koshy. *Community Relocation as an Option for Adaptation to the Effects of Climate Change and Climate Variability in Pacific Island Countries (PICs)*. Hamilton, New Zealand: Asia-Pacific Network for Global Change Research, 2007.

Cocks, Michelle, Tony Dold, Rosalie Kingwill, Maura Andrew, Lungisa Bosman, Charlie Shackleton, and Sheona Shackleton. "Baviaanskloof Mega-Reserve Project Study Area." Research Report. Baviaanskloof Mega-Reserve Project Management Unit, 2007.

Cocks, Michelle L., and K. Freerks Wiersum. "The Significance of Plant Diversity to Rural Households in Eastern Cape Province of South Africa." *Forests, Trees and Livelihoods* 13, no. 1 (2003): 39–58.

Cousins, Ben. "Invisible Capital: The Contribution of Communal Rangelands to Rural Livelihoods in South Africa." *Development Southern Africa* 16, no. 2 (1999): 299–318.

Cousins, Ben, and Thembela Kepe. "Decentralisation When Land and Resource Rights Are Deeply Contested: A Case Study of the Mkambati Eco-Tourism Project on the Wild Coast of South Africa." *The European Journal of Development Research* 16, no. 1 (2004): 41–54.

Crane, Wendy. "Biodiversity Conservation and Land Rights in South Africa: Whither the Farm Dwellers?" *Geoforum* 37, no. 6 (November 2006): 1035–45. doi:10.1016/j.geoforum.2006.07.002.

Crate, S. A., and M. Nuttall. *Anthropology and Climate Change: From Encounters to Actions*. Left

Coast Press, 2009.
Ebi, K. L., and J. C. Semenza. "Community-Based Adaptation to the Health Impacts of Climate Change." *American Journal of Preventive Medicine* 35, no. 5 (2008): 501–7.
Eriksen, S. H., and K. Brown. *Sustainable Adaptation to Climate Change: Prioritising Social Equity and Environmental Integrity*. Toronto, Canada: Earthscan Canada, 2011.
Faubion, J. D., and G. E. Marcus. *Fieldwork Is Not What It Used to Be: Learning Anthropology's Method in a Time of Transition*. Cornell, NY, USA: Cornell University Press, 2009.
Forest, Félix, Richard Grenyer, Mathieu Rouget, T. Jonathan Davies, Richard M. Cowling, Daniel P. Faith, Andrew Balmford, John C. Manning, Michelle van der Bank, and Gail Reeves. "Preserving the Evolutionary Potential of Floras in Biodiversity Hotspots." *Nature* 445, no. 7129 (2007): 757–60.
Füssel, Hans-Martin, and Richard JT Klein. "Climate Change Vulnerability Assessments: An Evolution of Conceptual Thinking." *Climatic Change* 75, no. 3 (2006): 301–29.
Geschiere, P., B. Meyer, and P. Pels, eds. *Readings in Modernity in Africa*. London, UK: International African Institute, 2008.
Gunderson, L., and C. S. Holling. *Panarchy Synopsis: Understanding Transformations in Human and Natural Systems*. Washington, D.C.: Island Press, 2002.
Hawn, Amanda. "South Africa Puts the Unemployed to Work, Restoring Land and Water." *The New York Times*, July 26, 2005, sec. F.
Hobbs, Benjamin F., Stuart A. Ludsin, Roger L. Knight, Phil A. Ryan, Johann Biberhofer, and Jan JH Ciborowski. "Fuzzy Cognitive Mapping as a Tool to Define Management Objectives for Complex Ecosystems." *Ecological Applications* 12, no. 5 (2002): 1548–65.
Hulme, Mike. "How Climate Models Gain and Exercise Authority." In *The Social Life of Climate Change Models: Anticipating Nature*, edited by K. Hastrup and M. Skrydstrup, 30–44. Routledge Studies in Anthropology. London, UK: Routledge, 2012.
Keilman, N. "Household Concepts and Household Definitions in Western Europe: Different Levels but Similar Trends in Household Developments." In *Household Demography and Household Modeling*, edited by E. van Imhoff, A. Kuijsten, P. Hooimeijer, and L. van Wissen, 111–35. New York, NY, USA: Springer, 1995.
Kirby, R. Kenneth. "Phenomenology and the Problems of Oral History." *Oral History Review* 35, no. 1 (2008): 22–28.
Kosko, Bart. "Fuzzy Cognitive Maps." *International Journal of Man-Machine Studies* 24, no. 1 (1986): 65–75.
Laukkonen, Julia, Paola Kim Blanco, Jennifer Lenhart, Marco Keiner, Branko Cavric, and Cecilia Kinuthia-Njenga. "Combining Climate Change Adaptation and Mitigation Measures at the Local Level." *Habitat International* 33, no. 3 (2009): 287–92.
Low, P. S., ed. *Climate Change and Africa*. Cambridge, UK: Cambridge University Press, 2005.
Magee, T. *A Field Guide to Community Based Adaptation*. New York, NY, USA: Taylor & Francis Group, 2013.
McPhee, J. *Basin and Range*. New York, NY, USA: Macmillan, 1982.
McPherson, Miller, Lynn Smith-Lovin, and James M Cook. "Birds of a Feather: Homophily in Social Networks." *Annual Review of Sociology* 27, no. 1 (August 2001): 415–44. doi:10.1146/annurev.soc.27.1.415.
Morgan, D. O. *The Cell Cycle: Principles of Control*. London, UK: New Science Press, 2007.
Muttlak, Hassen A. "Investigating the Use of Quartile Ranked Set Samples for Estimating the Population Mean." *Applied Mathematics and Computation* 146, no. 2 (2003): 437–43.

Odum, Howard T. *Environment, Power and Society*. New York, NY, USA: Wiley-Interscience, 1971.
Palutikof, J., S. L. Boulter, A. J. Ash, M. S. Smith, M. Parry, M. Waschka, and D. Guitart, eds. "The Past, Present and Future of Adaptation: Setting the Context and Naming the Challenges." In *Climate Adaptation Futures*. New York, NY, USA: Wiley, 2013.
Parker, Wendy S. "Predicting Weather and Climate: Uncertainty, Ensembles and Probability." *Studies In History and Philosophy of Science Part B: Studies In History and Philosophy of Modern Physics* 41, no. 3 (2010): 263–72.
Parry, Martin Lewis, Osvaldo F. Canziani, Jean P. Palutikof, Paul J. van der Linden, and Clair E. Hanson. *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Cambridge, UK: Intergovernmental Panel on Climate Change, 2007.
Perz, S. G., L. Cabrera, L. A. Carvalho, J. Castillo, R. Chacacanta, R. E. Cossio, Y. F. Solano, J. Hoelle, L. M. Perales, and I. Puerta. "Regional Integration and Local Change: Road Paving, Community Connectivity, and Social–ecological Resilience in a Tri-National Frontier, Southwestern Amazonia." *Regional Environmental Change* 12, no. 1 (2012): 35–53.
Rappoport, Roy. *Pigs for the Ancestors*. New Haven, CT, USA: Yale University Press, 1967.
Ratzel, Friedrich. *Anthropo-Geographie, Oder Grundzüge Der Anwendung Der Erdkunde Auf Die Geschichte*. Stuttgart, Germany: Verlag von J. Engelhorn, 1882.
Rayner, G. "Conventional and Ecological Public Health." *Public Health* 123, no. 9 (2009): 587–91.
Redman, Charles L. "Resilience Theory in Archaeology." *American Anthropologist* 107, no. 1 (2005): 70–77.
Rojas, Carolina, Joan Pino, Corina Basnou, and Mauricio Vivanco. "Assessing Land-Use and-Cover Changes in Relation to Geographic Factors and Urban Planning in the Metropolitan Area of Concepción (Chile). Implications for Biodiversity Conservation." *Applied Geography* 39 (2013): 93–103.
Roncoli, Carla, Todd Crane, and Ben Orlove. "Fielding Climate Change in Cultural Anthropology." In *Anthropology and Climate Change: From Encounters to Actions*, edited by S. A. Crate and M. Nuttall, 87–115. Walnut Creek, CA, USA: Left Coast Press, 2009.
Salamone, Frank A. "The Methodological Significance of the Lying Informant." *Anthropological Quarterly*, 1977, 117–24.
Salih, A. M. *Local Climate Change and Society*. New York, NY, USA: Taylor & Francis, 2012.
Saradamoni, Kunjulekshmi. *Finding the Household*. Thousand Oaks, CA, USA: SAGE Publication, 1992.
Schneider, Stephen H. "Climate Change and the World Predicament: A Case Study for Interdisciplinary Research." *Climatic Change* 1, no. 1 (1977): 21–43.
Schreier, M. *Qualitative Content Analysis in Practice*. Thousand Oaks, CA, USA: SAGE Publications, 2012.
Schutte, Sebastian, and Karsten Donnay. "Matched Wake Analysis: Finding Causal Relationships in Spatiotemporal Event Data." *Political Geography* 41 (2014): 1–10.
Scoones, Ian. *Sustainable Rural Livelihoods: A Framework for Analysis*. Vol. 72. Brighton, UK: Institute of Development Studies, 1998.
Shackleton, Charlie M., Sheona E. Shackleton, and Ben Cousins. "The Role of Land-Based Strategies in Rural Livelihoods: The Contribution of Arable Production, Animal Husbandry and Natural Resource Harvesting in Communal Areas in South Africa." *Development Southern Africa* 18, no. 5 (2001): 581–604.
Shackleton, C. M., and S. E. Shackleton. "The Importance of Non-Timber Forest Products in Rural Livelihood Security and as Safety Nets: A Review of Evidence from South Africa." *South*

African Journal of Science 100, no. 11 & 12 (2004): 658–64.

Shields, C. *The Oxford Handbook of Aristotle*. New York, NY, USA: Oxford University Press, 2012.

Simões, André Felipe, Debora Cynamon Kligerman, Emilio Lèbre La Rovere, Maria Regina Maroun, Martha Barata, and Martin Obermaier. "Enhancing Adaptive Capacity to Climate Change: The Case of Smallholder Farmers in the Brazilian Semi-Arid Region." *Environmental Science & Policy* 13, no. 8 (2010): 801–8.

Smit, Barry, Ian Burton, Richard JT Klein, and Johanna Wandel. *An Anatomy of Adaptation to Climate Change and Variability*. New York, NY, USA: Springer, 2000.

Smit, Barry, and Johanna Wandel. "Adaptation, Adaptive Capacity and Vulnerability." *Global Environmental Change* 16, no. 3 (2006): 282–92.

Statistics South Africa. "Census 2011." Statistical Release. Pretoria, South Africa: Statistics South Africa, 2012.

Steward, Julian, ed. "The Concept and Method of Cultural Ecology." In *The Concept and Method of Cultural Ecology*, 30–42. Urbana, IL, USA: University of Illinois Press, 1955.

Suttles, Gerald D., and Gerald Dale Suttles. *The Social Construction of Communities*. Vol. 111. University of Chicago Press Chicago, 1972.

Thomas, D. S. G., and C. Twyman. "Equity and Justice in Climate Change Adaptation amongst Natural-Resource-Dependent Societies." *Global Environmental Change* 15, no. 2 (2005): 115–24.

Turner, Nancy J., Iain J. Davidson-Hunt, and Michael O'Flaherty. "Living on the Edge: Ecological and Cultural Edges as Sources of Diversity for Social—ecological Resilience." *Human Ecology* 31, no. 3 (2003): 439–61.

Turner, R. A., A. Cakacaka, N. A. J. Graham, N. V. C. Polunin, M. S. Pratchett, S. M. Stead, and S. K. Wilson. "Declining Reliance on Marine Resources in Remote South Pacific Societies: Ecological versus Socio-Economic Drivers." *Coral Reefs* 26, no. 4 (2007): 997–1008.

Uy, Noralene, Rajib Shaw, and Yukiko Takeuchi. "Chapter 8 Livelihoods: Linking Livelihoods and Ecosystems for Enhanced Disaster Management." In *Community, Environment and Disaster Risk Management*, 9:131–43. Bingley: Emerald Group Publishing. Accessed February 8, 2013.

Van Ecke, B., O. Selomane, D. Broeck, M. Zijlstra, and RS de Groot. *Cultivating the "PRESENCE" Learning Network to Restore Living Landscapes Adapting to Climate Change in the Baviaanskloof Catchment, South Africa*. Gland, Switzerland: IUCN, 2010.

Vickers, D. *Economics and the Antagonism of Time: Time, Uncertainty, and Choice in Economic Theory*. Ann Arbor, MI, USA: University of Michigan Press, 1994.

Walker, Brian, Lance Gunderson, Ann Kinzig, Carl Folke, Steve Carpenter, and Lisen Schultz. "A Handful of Heuristics and Some Propositions for Understanding Resilience in Social-Ecological Systems." *Ecology and Society* 11, no. 1 (2006): 13.

Wisner, Ben. "Tracking Vulnerability: History, Use, Potential and Limitations of a Concept." Invited Keynote Address presented at the SIDA & Stockholm University, Research Conference, Stockholm, Sweden, 2005.

Wissler, C. *The Relations of Man to Nature in Aboriginal America*. New York, NY, USA: Oxford University Press, 1926.

Wood, Charles H. "Keeping Time: Temporal Hierarchies in Socio-Ecological Systems." In *Nature, Raw Materials, and Political Economy: Research in Rural Sociology and Development*, edited by Paul S. Ciccantell, David S. Smith, and Gay Seidman, 10:93–112. Bingley, UK: Emerald Group Publishing Limited, 2005.

———. "Time, Cycles and Tempos in Social-Ecological Research and Environmental Policy." *Time & Society* 17, no. 2–3 (September 1, 2008): 261–82. doi:10.1177/0961463X08093425.