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A Household Social Vulnerability Index (HSVI) for Evaluating Adaptation Projects in Developing Countries

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Abstract

The world is already committed to human-induced climate change resulting from past emissions, and to reduce its adverse impacts adaptation will thus be required, particularly in the developing world, and particularly at the local level. However, whilst there is agreement on the need for adaptation, how to define it, and how to implement it, is still poorly articulated. The aim of adaptation interventions is to reduce vulnerability to climate change, and adaptation typically takes place at the local scale. As vulnerability is a potential state, only manifest in response to a specific climate hazard (either now or in the future), there is a need to develop methodological tools to evaluate whether adaptation interventions do, in fact, reduce vulnerability. Indicators of household level vulnerability are thus required in order to chart the degree of change in potential vulnerability from before the adaptation interventions (the baseline scenario) until after the changes have been made. The use of such indicators has important policy relevance in ensuring that adaptation interventions do indeed contribute to sustainable and equitable development.

The paper outlines a theoretically-derived index of household level social vulnerability to climate change, based on the multiple dimensions of vulnerability identified in the sustainable livelihoods framework (based on access to natural, human, physical, financial and social capital). The index is formed from the weighted aggregation of 5 composite sub-indices, themselves formed from one or more indicators. The paper exemplifies the use of the index in a rural dryland setting in South Africa, where the climate hazard is changes in water availability; but the theoretical derivation of the index means that, within the general structure, indicators can be chosen as appropriate to the context, and thus the tool is highly adaptable to different settings. The final score is not absolute (given vulnerability is a potential state), but rather a relative ranking of all households. In this way it is appropriate both to identify households with the highest relative vulnerability to target adaptation interventions, and also to evaluate the success of such interventions in reducing vulnerability over the life of the project.

Introduction

The world is already committed to human-induced climate change resulting from past emissions, the scope of which will expand unless substantial mitigation measures are introduced. Although the Kyoto Protocol exists, and discussions relating to a successor agreement have been taking place under the UNFCCC for some time, the current reduction commitments in greenhouse gas emissions are insufficient. International policy frameworks fall far below the 30% aggregate reduction required by developed and

developing countries to limit "dangerous" climate change, defined as a 2°c increase in temperature (Pachauri et al, 2007) There is thus an indisputable need for societies to adapt to at least some degree of climate change, and the need for this adaptation is arguably most imperative in the developing world, where climate change threatens to undo recent developmental progress amongst the world's most vulnerable.

The recognition of the need for adaptation, particularly in the developing world, has been taken up in the climate change policy frameworks and by development agencies. Conceptualisation of adaptation within policy frameworks has progressed (Schipper, 2006) such that there is now acceptance that developed countries, who are responsible for the historical emissions that bring about climate change, recognise their commitment to compensating developing countries for the costs of adaptation to these changes. Indeed, such commitments of funding have been forthcoming, particularly at the 15th Conference of the Parties to the UNFCCC in Copenhagen in December 2009[1].

Likewise, many development agencies, including multilateral organisations such as the UN, bilateral donors, and NGOs have committed to promoting adaptation through mainstreaming with development programmes (DFID, 2009; Gigli and Agrawala, 2007; Klein et al, 2007; OECD, 2006). However, whilst there is growing commitment to the need for adaptation, how to define it, and how to implement it, is still poorly articulated. Particular overlaps exist between adaptation and development (McGray et al, 2007; Schipper, 2007; Schipper and Pelling, 2006;). Some household level development interventions have been "rebranded" as adaptation in an attempt to gain access to new funding sources, and this is enabled by the intangible nature of adaptation, and the fact that their success can only really be noticed in times of future climate change (if the adaptive capacity is successfully translated in the face of hazard exposure into adaptation).

The aim of adaptation interventions is to reduce vulnerability to climate change. As vulnerability is a potential state, only manifest in response to a specific climate hazard (either now or in the future), there is a need to develop methodological tools to evaluate whether adaptation interventions do, in fact, reduce vulnerability. Indicators of vulnerability are thus required in order to chart the degree of change in potential vulnerability from before the adaptation interventions (the baseline scenario) until after the changes have been made. The use of such indicators has important policy relevance in ensuring that adaptation interventions do indeed contribute to sustainable and equitable development. This paper presents a theoretically-derived index of household level social vulnerability (HSVI) to climate change, that was created for use in a rural dryland context in Limpopo province, South Africa, but whose structure is transferable to other contexts. The theoretical derivation means that, within the general structure, composite sub-indices, indicators and weightings can be modified to be context-specific. As a result, it can be used both to identify households with the highest relative vulnerability to target adaptation interventions, and also to monitor and evaluate the success of such interventions in reducing vulnerability over the life of the project.

[1] For a review of funds available to developing countries, see http://www.climatefundsupdate.org/

Approaches to vulnerability

The field of vulnerability science has emerged relatively recently and has its origins in several different bodies of literature, which have been reviewed by a number of researchers (Füssel, 2007; Adger, 2006 ; Eakin and Luers, 2006). Consequently, a variety of definitions have been proposed (Cutter, 1996a). One comprehensive definition describes vulnerability as the state of susceptibility to harm from exposure to stresses associated with environmental and social change and from the absence of capacity to adapt (Adger, 2006). Until the Third Assessment Report of the IPCC, vulnerability was taken to be the risk of exposure of an ecosystem to a hazard (McCarthy et al., 2001). However, the approach attracted criticism through assuming humans are passive recipients of global environmental change, and thus failing to capture their dynamic ability to mediate such hazards, either through resisting an event or coping once it occurs (Stonich, 2000).

Rather than being passive recipients of global environmental change, the social vulnerability school of thought recognises that physical phenomena are embedded in, and mediated by, the particular human context in which they occur. Facets of this human context relate to the social, political, economic and institutional environment, and the factors that shape the allocation of, and access to, resources (Pelling and Uitto, 2001). In the well-developed food security literature famines have been explained on the basis of entitlement theory (Sen, 1981), where the distribution and reproduction of entitlements is dependent on the structural factors of political economy that precipitate entitlement failure (Bohle et al., 1994; Downing, 1996; Watts & Bohle, 1993). In the face of exposure to climate change, some populations will be able to draw on their entitlements to adapt to the risk, for example through awareness and preparation, insurance for losses, and diversifying livelihoods. Populations with strong institutions may also be able to deal with a hazard effectively and reduce, if not stop completely, the biophysical effects translating into human impacts (Handmer et al., 1999). But this is very dependent on the scale of enquiry.

The structures that affect asset allocation in society may play out differently at the sub-national level. Collective vulnerability (at community level or higher) to extremes in coastal Vietnam is determined by institutional and market structures (Adger, 1999). In contrast, at the local scale, the role of human agency has a greater influence in access to resources and household level social status. In such cases it is important to look at the rules by which claims can be made over certain resources (Leach et al., 1999). Entitlements are socially and spatially differentiated according to such factors as gender, ethnicity, religion, class and age (Denton, 2002; Enarson, 2000; Cutter, 1995; Wisner, 1998). The fact that vulnerability is embedded in wider processes also creates the opportunity for reduction or increase through the social amplification of risk (Kasperson et al., 1995).

Whilst physical phenomena are necessary for the production of a natural hazard, their translation into risk and potential for disaster is contingent upon human exposure and a lack of capacity to cope with the negative impacts that exposure might bring to individuals or human systems (Pelling, 2000). This broader approach thus highlights

the importance of assessing the complex reality of vulnerability when predicting future impacts of environmental change as the most vulnerable people may not be in the most vulnerable places: poor people can live in resilient biophysical environments and be vulnerable, and wealthy people can be in fragile physical environments and live relatively well (Liverman, 1994). Understanding the impacts of climate change is thus inextricably linked with the human conditions that create a resilience or vulnerability to that event (Parry & Carter, 1998).

Social vulnerability, in contrast to being seen as an outcome, is viewed more as a potential state of human societies that can affect the way they experience natural hazards (O'Brien et al, 2004; Adger, 1999; Adger & Kelly, 1999; Blaikie et al., 1994). This potential state is in constant flux, reflecting its dependence on the dynamic interaction of a range of economic and social processes which influence the capacity of individuals, social groups, sectors, regions and ecosystems to respond to various socio-economic and biophysical shocks (Comfort et al., 1999; Leichenko & O'Brien, 2002). The most vulnerable are considered to be those who are most exposed to perturbations, who possess a limited coping capacity and who are least resilient to recovery (Bohle et al., 1994). Other definitions of vulnerability focus on concepts of marginality, susceptibility, adaptability, fragility and risk (Liverman, 1994). As far as adaptation is concerned, its purpose is to reduce vulnerability to climate change that might be experienced, now or in the future.

Measuring the multiple drivers of vulnerability

When vulnerability is taken to be a potential state of human societies, context-specific methods of assessment are required to assess the levels of vulnerability. That said, it is now widely recognised that there are multiple driving forces of vulnerability in relation to specific outcomes (Adger and Vincent, 2005). The sustainable livelihoods framework can be used for assessing local level vulnerability and adaptive capacity through analysing the status of five "capital assets" – financial, human, social, physical and natural (Chambers & Conway, 1992). The sustainable livelihoods framework arose as a holistic tool that promotes multi-dimensional understanding of the nature and dynamics of livelihood vulnerability. Livelihoods in this context refer not only to income but also the social institutions, gender relations and property rights necessary to support a standard of living (Ellis, 1998). The sustainable livelihoods framework has variously been applied to investigate the contextual and multi-dimensional nature of vulnerability (O'Brien et al, 2009; Reid & Vogel, 2006; Ziervogel & Calder, 2003; Francis, 2002; Waite, 2000).

This paper explains a household social vulnerability index that was created for use in a village (Maangani) in a dryland context in Limpopo province, South Africa. Being theory-driven and based on the sustainable livelihoods framework, the component sub-indices each represent one of the five assets: social capital, human capital, physical capital, financial capital and natural capital. Two of the five sub-indices are themselves equally weighted aggregations of two component indicators. The weights applied in the aggregation of both the component sub-indices (where applicable) and the final vulnerability index derives from a period of participant observation within the case

study location, combined with theoretical insights into the determinants of vulnerability. This paper argues that the overall structure and theoretical derivation of this index is transferable to other places, even if the specific indicators, sub-index structure and weights need modification to be appropriate to local context.

Increasingly indicators have been used to assess vulnerability, both at the national and local scale. At the national level, indicators have been embraced for empirically assessing social as well as biophysical vulnerability. These exist on a region specific basis for economic and social vulnerability (Vincent, 2004; Crowards, 1999; Easter, 1999; Kaly *et al.*, 1999; Briguglio, 1995), as well as specifically for climate change (Brooks et al., 2005; Yohe & Tol, 2002; Downing et al., 2001; Moss et al., 2001;). However the range and extent of indicators varies from study to study (Eriksen and Kelly, 2007). Complex analyses incorporating multiple stressors have been carried out at the local level in various locations (Hahn et al, 2009; Bankoff et al., 2004; Cutter, 1996b. But the scale specificity of indicators means that it is often not methodologically possible to apply the exact frameworks across different units of analysis (Vincent, 2007).

The relationship between natural capital and vulnerability to climate change is arguably one of the least contested. The greater the level of reliance of a household on natural resources, such as farming, fishing, or forestry, the greater their vulnerability to climate change. This is because the availability of such natural resources is dependent on climatic variables such as rainfall, which are projected to change under climate change. It is likely that the level of dependence on natural resources will vary from household to household: for some households farming constitutes the main base of their livelihood; for others it is an equal or lesser contributor alongside other economic activities; and several households do not participate in farming at all. For this indicator each household is therefore classified in nominal categories, whereby 1 indicate the most vulnerable households (with total dependence on agriculture), 2 indicates medium vulnerability (partial dependence) and 3 indicates low vulnerability (no dependence on agriculture) in the Limpopo case study.

Similarly the relationship between financial capital and vulnerability to climate change is clear-cut: the lower the level of financial resources available to a household, the higher the level of their vulnerability, since they would likely be unable to afford changes to their livelihoods in case of hazard exposure. There are various potential indicators of financial capital: ideally a quantitative analysis of the annual household budget (the degree of difference between income and outgoings) could be used. When operationalising the theory, however, some data limitations come into play. In this example in Limpopo province, for example, data collection was based around a questionnaire incorporating livelihoods survey, and all information on outgoings and income over the year was thus based on recall. Given the inherent errors in making such an estimation, this indicator was deemed too uncertain. Other potential indicators could be the socio-economic gradings of occupations, but with multi-generational households predominant it is not always possible to assume the extent to which formal sector income from an adult son or daughter actively contributes to the household income, hence this might be deemed even more uncertain than the household head-expressed economic income. It is well-known that in African societies livestock

represent an accumulation of wealth (Reardon et al, 1988; Swinton, 1988). The indicator chosen to capture economic well-being in the household level index is thus the value of livestock assets (including cattle, goats, donkeys, pigs and chickens).

In terms of human capital, various elements can be seen to influence vulnerability to climate change. One element is the demographic structure of the household: households with a high degree of dependency, whether through children, the elderly, or the infirm, are likely to be more vulnerable to climate change as they are already in the precarious position of having a relatively small number of economically active adults. One indicator of vulnerability through human capital is thus the intra-household dependency ratio. In the case study example, schooling in South Africa is compulsory until at least age 16, but education is highly regarded in a society where unemployment is high; and thus very few leave before obtaining their matriculation certificate (at least at age 18). Thus those under 18 are deemed to be dependent. Similarly, the age for elderly dependence was the age of eligibility for receiving the national social pension. At the time of this research, that was age 60 for women and age 65 for men, and thus household members over these ages are also deemed to be dependent. It is, however, worth mentioning that the increased availability and value of pensions since 1994 has arguably led to dependency ratios being turned on their heads in some cases, with many multi-generational families relying on them as a major source of income (Moller and Sotshongaye, 1996). Whilst it is important to make indicators sensitive to difference, this need is in tension with the need for comparability. In order to make this index feasible for use in other similar villages, no modification was made to the elderly dependent age. In addition dependence within the household refers to more than just economic, and the reduced human capacities of the elderly mean that time of working age members, typically the women, is constrained by the need to assist with their personal care.

Whilst dependency ratio is one indicator of vulnerability through human capital, another important consideration, particularly in sub-Saharan Africa, is the health of the household members. In the same way that the young and elderly are dependent, any household members with chronic illness are similarly dependent, even if they are of working age. In terms of operationalising this theory in the case study example, South Africa has a high prevalence of HIV/AIDS (Kauffman, 2004; Lurie, 2004), and the long-term and debilitating nature of this disease in particular affects dependency. Persistent taboos around HIV/AIDS at the local level means that there is still often reluctance to admitting being infected so the indicator used to represent this in the demographic structure sub-index of the HSVI is thus whether or not a household has a member who is suffering from a long term or recurrent illness. The types of illnesses occurring within the village include diabetes, epilepsy and high blood pressure, although only 12.95% of households are affected. Although this is a small proportion, and the resulting data is only a nominal classification of “yes” or “no”, it is still an important determinant of a household’s adaptive capacity, and thus has been included in the weighted aggregate index.

Social capital is also important in determining vulnerability. Social capital refers to norms, networks and reciprocal relationships (Bourdier, 1985, Putnam, 1993).

Theoretically, the greater the number of these, the lower a household's vulnerability since, in the case of hazard exposure, there will be resources that can be called upon in order to ensure survival and coping. As with previous capitals, indicators must be sought that reflect this theoretical relationship whilst also being appropriate to the local context so as to differentiate between different amounts of social capital. At the local level in this case study in Limpopo province, those households whose contacts and knowledge is based around the village will be more vulnerable to climate exposure than those whose networks extend over a greater geographical range and connect with a wider variety of institutions (Adger, 2003). This is particularly the case in a young democracy where the formal governance structures are now accessible to people of all racial groups, and growing to co-exist with the traditional tribal authorities (King, 2005). The greater the social capital of a household, the more likely they are to have contact with more worldly persons who are more aware of their increased opportunities. As a largely intangible concept, social capital is difficult to measure and various proxies have been proposed and used (Durlauf, 2002; Woolcock, 2002; Paldam, 2000). It has been suggested that indicators be selected based on the cultural context (Krishna, 2001), and thus those used in this sub-index were based on substantial experience of living in the village and observing interactions and developed from responses to the survey.

The two component indicators for the social capital sub-index are the range of contacts, and the number of groups to which the household head belongs, each contributing 10% of the weight to the final aggregate index. For range of contacts, each household has been placed in one of four groups, depending on the geographical range and extent of access to both bonding social capital (kin and friendship ties) and networking social capital (traditional and formal governance structures). The lowest score of 1, indicating the least adaptive capacity, means that a household's social capital is based on friends and family and/or traditional leadership within the village. The highest score of 4, indicating the greatest adaptive capacity, means that a household has access to a wide range of both friends and family, and traditional and formal governance structures (e.g. the local ward councillor), and that these contacts range beyond the geographical limits of the village.

The above selection of nominal groups of answers has also been applied to the other component indicator for social capital - number of groups to which the household head belongs (Pretty and Ward, 2001). This indicator reflects adaptive capacity in two ways. Firstly membership in local groups, which can include burial societies, women's wheels and saving groups, is a measure of the range of social safety nets to which a household has access. Furthermore, the entire range of these groups, but burial societies in particular, function as a kind of informal grassroots insurance, the type of which would be crucial in the case of a climatic-related risk exposure. Secondly, membership entails regular fee payments, and so the mere fact that a household can afford to pay this reflects their economic priorities. Household responses have again been divided into four groups: a score of 1 is accorded if a household head is a member of no groups, 2 in the case of one group, 3 in the case of two groups, and 4 in the case of three groups or more. By taking into account the interconnectedness between households and informal and formal systems of governance, in a way this sub-index also captures the elements of political capital.

Physical capital is another example where a number of potential indictors could be chosen. Typically physical capital can refer to the number of assets owned by a household, such as farming implements, or it can relate to the quality of housing. The village in which this index is developed is situated next to a river in the Limpopo basin, and recent experience in the major 2000 floods showed that housing quality was indeed a differential factor of vulnerability in the face of exposure to that particular hazard. Those living in mud huts were far more vulnerable than those with brick houses. As in many parts of Africa, people's houses in this village are built up and improved over time, as funds become available. Again the best means of differentiating them is to divide into 3 categories of different standards; such that houses classed as group one are made predominantly of mud with grass roofs, whereas those in group three are constructed of brick with tile roofs, and are thus less vulnerable to flooding.

Structure of the Household Social Vulnerability Index

The index presented here is thus theory-driven, comprising the weighted aggregate of a number of component sub-indices. An important distinction is between aggregate indices, where the constituent parts are not recognisable, and composite indices, where they are (Jollands & Paterson, 2003). The household index of vulnerability combines both approaches, providing a simple final aggregate score, but demonstrates a commitment to transparency of the makeup of that figure through the composite sub-indices. Primary data is derived from a questionnaire incorporating livelihoods survey to evaluate levels of current vulnerability at a household level. Some of the indicators represent discrete data sets, and others normative groups, but in all cases the final aggregate score is standardised across the range of data. In short, the vulnerability index is formed from the weighted average of five composite sub-indices: financial capital (20%); human capital (20%); social capital (20%); natural capital (20%); and physical capital (20%) (see figure 1)

The result is that the index of vulnerability gives an ordinal ranking of aggregate vulnerability for each of the 85 sample households, whilst maintaining commitment to transparency in the make-up of those scores. It is therefore possible to analyse by household headship both the aggregate vulnerability and the components that make up that vulnerability. This is important for showing how accumulation of one type of asset can counteract the absence of another in the final ranking, and showing how accumulation of capital assets within the sustainable livelihoods framework are gendered. Table 1 outlines the results of the Household Social Vulnerability Index.

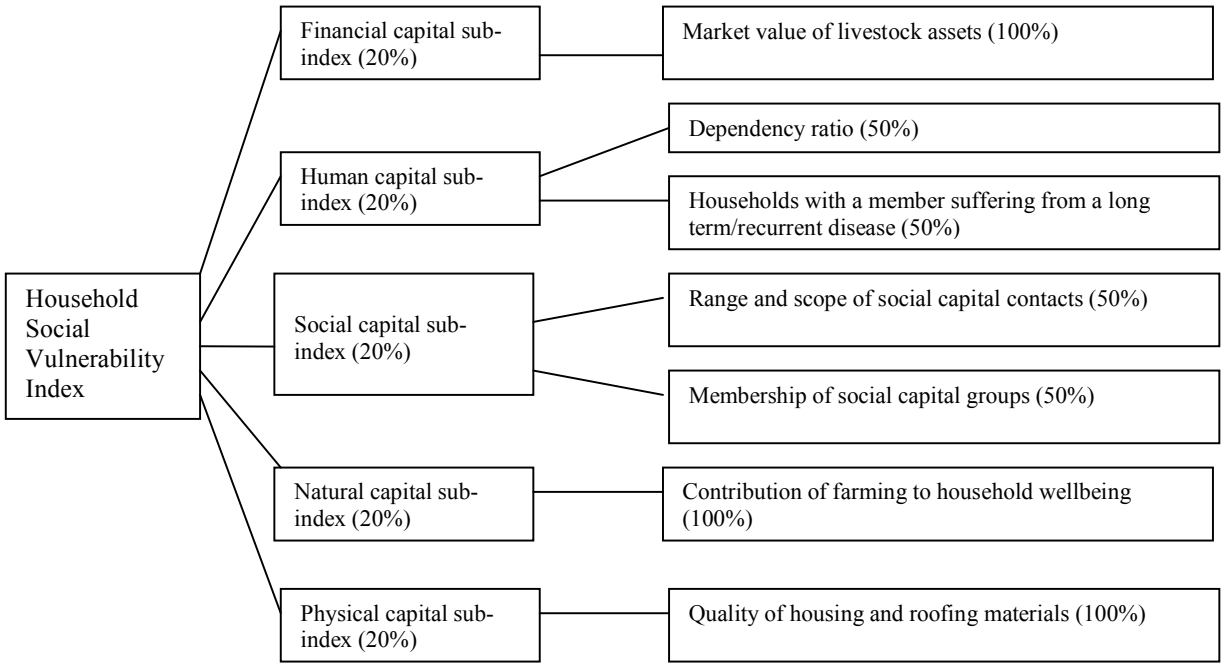

Figure 1: Structure of the SVI

Table 1: Results of the Household Social Vulnerability Index for Maangani, South Africa

Household number	**Vulnerability Index**	**Vulnerability Rank**	**Human capital**						**Physical capital**		**Financial capital**			**Social capital**				**natural capital**	
			Dependency ratio	working population	dependent population	**rank dependency ratio**	Illness	**rank illness**	House category	**rank house**	livestock assets	transposed livestock so 1 = most vuln	**rank livestock**	Social capital-contacts	**rank social capital-contacts**	Social capital-groups	**rank social capital-groups**	dependence on farming	**rank farming**
145	18.45	**1**	neg	0	3	**2.0**	0	**37.5**	1	**14.5**	0	1.000	**11.5**	3	**65.5**	1	**7.5**	1	**10.0**
81	21.70	**2**	300.00	1	3	**7.5**	0	**37.5**	1	**14.5**	50	0.999	**25.0**	3	**65.5**	1	**7.5**	1	**10.0**
134	23.80	**3**	150.00	2	3	**34.0**	0	**37.5**	1	**14.5**	0	1.000	**11.5**	1	**16.5**	2	**39.0**	2	**29.5**
69	24.80	**4.5**	200.00	1	2	**18.0**	0	**37.5**	1	**14.5**	350	0.996	**44.0**	1	**16.5**	2	**39.0**	1	**10.0**
66	24.80	**4.5**	300.00	2	6	**7.5**	1	**6.0**	1	**14.5**	0	1.000	**11.5**	1	**16.5**	2	**39.0**	3	**63.5**
132	25.20	**6**	120.00	5	6	**47.0**	0	**37.5**	1	**14.5**	225	0.998	**31.5**	1	**16.5**	2	**39.0**	1	**10.0**
151	25.70	**7**	125.00	4	5	**44.5**	0	**37.5**	1	**14.5**	175	0.998	**31.5**	1	**16.5**	1	**7.5**	2	**29.5**
76	27.50	**8**	200.00	3	6	**18.0**	0	**37.5**	1	**14.5**	240	0.997	**38.0**	1	**16.5**	2	**39.0**	2	**29.5**
67	27.95	**9**	300.00	1	3	**7.5**	0	**37.5**	1	**14.5**	0	1.000	**11.5**	1	**16.5**	2	**39.0**	3	**63.5**
127	29.20	**10**	100.00	2	2	**55.5**	0	**37.5**	1	**14.5**	1025	0.989	**52.0**	2	**38.5**	1	**7.5**	1	**10.0**
15	30.60	**11**	150.00	2	3	**34.0**	0	**37.5**	1	**14.5**	0	1.000	**11.5**	1	**16.5**	2	**39.0**	3	**63.5**
165	30.80	**12**	200.00	2	4	**18.0**	0	**37.5**	1	**14.5**	1125	0.988	**54.5**	1	**16.5**	2	**39.0**	2	**29.5**
169	30.90	**13.5**	200.00	2	4	**18.0**	0	**37.5**	1	**14.5**	325	0.996	**44.0**	2	**38.5**	2	**39.0**	2	**29.5**
155	30.90	**13.5**	250.00	2	5	**10.0**	0	**37.5**	1	**14.5**	50	0.999	**25.0**	1	**16.5**	2	**39.0**	3	**63.5**
80	31.65	**15**	166.67	3	5	**26.5**	0	**37.5**	2	**52.5**	0	1.000	**11.5**	3	**65.5**	2	**39.0**	1	**10.0**
159	31.80	**16**	100.00	3	3	**55.5**	1	**6.0**	2	**52.5**	300	0.997	**38.0**	1	**16.5**	2	**39.0**	1	**10.0**
141	32.00	**17**	150.00	2	3	**34.0**	0	**37.5**	1	**14.5**	0	1.000	**11.5**	3	**65.5**	3	**72.0**	2	**29.5**
77	32.30	**18**	neg	0	1	**2.0**	0	**37.5**	1	**14.5**	0	1.000	**11.5**	3	**65.5**	2	**39.0**	3	**63.5**
136	32.55	**19.5**	150.00	2	3	**34.0**	1	**6.0**	2	**52.5**	0	1.000	**11.5**	3	**65.5**	3	**72.0**	1	**10.0**

149	32.55	**19.5**	700.00	1	7	**4.5**	0	**37.5**	1	**14.5**	0	1.000	**11.5**	3	**65.5**	2	**39.0**	3	**63.5**
74	32.85	**21**	166.67	3	5	**26.5**	0	**37.5**	2	**52.5**	0	1.000	**11.5**	2	**38.5**	2	**39.0**	2	**29.5**
157	33.00	**22**	200.00	1	2	**18.0**	0	**37.5**	1	**14.5**	225	0.998	**31.5**	1	**16.5**	2	**39.0**	3	**63.5**
177	33.30	**23**	125.00	4	5	**44.5**	0	**37.5**	2	**52.5**	150	0.998	**31.5**	1	**16.5**	1	**7.5**	2	**29.5**
113	34.25	**24**	100.00	2	2	**55.5**	0	**37.5**	1	**14.5**	450	0.995	**48.0**	3	**65.5**	2	**39.0**	1	**10.0**
70	34.30	**25**	133.33	3	4	**41.0**	0	**37.5**	2	**52.5**	25	1.000	**11.5**	2	**38.5**	2	**39.0**	2	**29.5**
150	35.40	**26**	100.00	1	1	**55.5**	0	**37.5**	2	**52.5**	1450	0.984	**56.0**	1	**16.5**	1	**7.5**	1	**10.0**
137	36.30	**27**	150.00	2	3	**34.0**	0	**37.5**	2	**52.5**	0	1.000	**11.5**	3	**65.5**	2	**39.0**	2	**29.5**
83	36.75	**28**	neg	0	1	**2.0**	0	**37.5**	2	**52.5**	0	1.000	**11.5**	3	**65.5**	1	**7.5**	3	**63.5**
164	37.10	**29**	66.67	3	2	**69.5**	1	**6.0**	1	**14.5**	5675	0.937	**65.0**	2	**38.5**	2	**39.0**	2	**29.5**
20	37.25	**30**	200.00	2	4	**18.0**	0	**37.5**	1	**14.5**	400	0.996	**44.0**	3	**65.5**	1	**7.5**	3	**63.5**
118	38.25	**31**	300.00	1	3	**7.5**	0	**37.5**	2	**52.5**	50	0.999	**25.0**	1	**16.5**	2	**39.0**	3	**63.5**
135	38.40	**32**	200.00	3	6	**18.0**	0	**37.5**	2	**52.5**	1050	0.988	**54.5**	1	**16.5**	2	**39.0**	2	**29.5**
60	38.80	**33.5**	200.00	3	6	**18.0**	0	**37.5**	1	**14.5**	400	0.996	**44.0**	1	**16.5**	3	**72.0**	3	**63.5**
43	38.80	**33.5**	150.00	2	3	**34.0**	0	**37.5**	1	**14.5**	0	1.000	**11.5**	3	**65.5**	3	**72.0**	3	**63.5**
178	39.50	**35**	200.00	2	4	**18.0**	0	**37.5**	2	**52.5**	550	0.994	**49.0**	2	**38.5**	2	**39.0**	2	**29.5**
1	39.80	**36**	66.67	3	2	**69.5**	0	**37.5**	2	**52.5**	9500	0.895	**71.0**	1	**16.5**	1	**7.5**	1	**10.0**
128	40.00	**37.5**	233.33	3	7	**11.0**	0	**37.5**	2	**52.5**	100	0.999	**25.0**	3	**65.5**	3	**72.0**	2	**29.5**
173	40.00	**37.5**	133.33	3	4	**41.0**	0	**37.5**	3	**80.5**	150	0.998	**31.5**	2	**38.5**	2	**39.0**	1	**10.0**
179	40.40	**39**	150.00	2	3	**34.0**	0	**37.5**	2	**52.5**	0	1.000	**11.5**	2	**38.5**	2	**39.0**	3	**63.5**
78	40.85	**40.5**	100.00	1	1	**55.5**	0	**37.5**	1	**14.5**	975	0.989	**52.0**	1	**16.5**	2	**39.0**	3	**63.5**
154	40.85	**40.5**	700.00	1	7	**4.5**	0	**37.5**	3	**80.5**	0	1.000	**11.5**	1	**16.5**	2	**39.0**	3	**63.5**
88	40.95	**42**	100.00	3	3	**55.5**	0	**37.5**	2	**52.5**	1800	0.980	**57.0**	2	**38.5**	2	**39.0**	1	**10.0**
5	41.20	**43**	200.00	1	2	**18.0**	0	**37.5**	1	**14.5**	150	0.998	**31.5**	3	**65.5**	3	**72.0**	3	**63.5**
123	42.20	**44**	33.33	3	1	**79.0**	0	**37.5**	2	**52.5**	250	0.997	**38.0**	3	**65.5**	2	**39.0**	1	**10.0**
90	42.95	**45**	100.00	2	2	**55.5**	0	**37.5**	2	**52.5**	2600	0.971	**61.5**	1	**16.5**	3	**72.0**	1	**10.0**
57	43.10	**46.5**	150.00	2	3	**34.0**	0	**37.5**	2	**52.5**	0	1.000	**11.5**	3	**65.5**	2	**39.0**	3	**63.5**
122	43.10	**46.5**	150.00	2	3	**34.0**	0	**37.5**	2	**52.5**	0	1.000	**11.5**	3	**65.5**	2	**39.0**	3	**63.5**
176	43.70	**48**	200.00	2	4	**18.0**	0	**37.5**	1	**14.5**	325	0.996	**44.0**	3	**65.5**	3	**72.0**	3	**63.5**
111	44.05	**49**	50.00	2	1	**74.5**	0	**37.5**	2	**52.5**	12000	0.867	**74.0**	1	**16.5**	2	**39.0**	1	**10.0**
171	44.70	**50**	200.00	1	2	**18.0**	0	**37.5**	3	**80.5**	2000	0.978	**58.0**	1	**16.5**	2	**39.0**	2	**29.5**
27	44.90	**51**	133.33	3	4	**41.0**	0	**37.5**	2	**52.5**	100	0.999	**25.0**	1	**16.5**	3	**72.0**	3	**63.5**
116	44.95	**52**	166.67	3	5	**26.5**	0	**37.5**	1	**14.5**	32000	0.646	**80.0**	3	**65.5**	3	**72.0**	2	**29.5**
131	45.00	**53**	100.00	8	8	**55.5**	0	**37.5**	2	**52.5**	2400	0.973	**60.0**	3	**65.5**	1	**7.5**	2	**29.5**
61	45.05	**54**	100.00	4	4	**55.5**	1	**6.0**	2	**52.5**	250	0.997	**38.0**	3	**65.5**	4	**83.5**	2	**29.5**
51	45.75	**55**	100.00	2	2	**55.5**	0	**37.5**	1	**14.5**	1025	0.989	**52.0**	3	**65.5**	2	**39.0**	3	**63.5**
49	45.85	**56**	66.67	3	2	**69.5**	0	**37.5**	2	**52.5**	6425	0.929	**69.0**	1	**16.5**	3	**72.0**	1	**10.0**
170	46.75	**57**	75.00	4	3	**65.0**	1	**6.0**	2	**52.5**	4800	0.947	**64.0**	3	**65.5**	2	**39.0**	2	**29.5**
58	46.85	**58**	100.00	2	2	**55.5**	0	**37.5**	2	**52.5**	400	0.996	**44.0**	1	**16.5**	2	**39.0**	3	**63.5**
166	46.90	**59**	66.67	3	2	**69.5**	0	**37.5**	1	**14.5**	6000	0.934	**66.5**	3	**65.5**	1	**7.5**	3	**63.5**
24	47.40	**60**	100.00	2	2	**55.5**	1	**6.0**	2	**52.5**	290	0.997	**38.0**	3	**65.5**	2	**39.0**	3	**63.5**
75	47.55	**61.5**	0.00	1	0	**84.0**	0	**37.5**	2	**52.5**	24000	0.734	**78.0**	3	**65.5**	1	**7.5**	1	**10.0**
130	47.55	**61.5**	150.00	6	9	**34.0**	0	**37.5**	2	**52.5**	0	1.000	**11.5**	3	**65.5**	4	**83.5**	3	**63.5**
84	48.30	**63**	33.33	3	1	**79.0**	0	**37.5**	3	**80.5**	0	1.000	**11.5**	1	**16.5**	2	**39.0**	3	**63.5**
56	48.40	**64.5**	166.67	3	5	**26.5**	0	**37.5**	2	**52.5**	37500	0.585	**82.0**	1	**16.5**	1	**7.5**	3	**63.5**
168	48.40	**64.5**	66.67	3	2	**69.5**	0	**37.5**	2	**52.5**	8000	0.911	**70.0**	4	**65.5**	1	**7.5**	2	**29.5**
12	48.60	**66**	100.00	2	2	**55.5**	1	**6.0**	2	**52.5**	375	0.996	**44.0**	3	**65.5**	2	**39.0**	3	**63.5**
139	49.60	**67.5**	83.33	6	5	**64.0**	0	**37.5**	2	**52.5**	3300	0.963	**63.0**	3	**65.5**	2	**39.0**	2	**29.5**
39	49.60	**67.5**	66.67	3	2	**69.5**	1	**6.0**	2	**52.5**	6000	0.934	**66.5**	1	**16.5**	2	**39.0**	3	**63.5**
180	51.35	**69**	100.00	3	3	**55.5**	0	**37.5**	3	**80.5**	26410	0.971	**61.5**	2	**38.5**	2	**39.0**	2	**29.5**
29	51.45	**70.5**	125.00	4	5	**44.5**	0	**37.5**	2	**52.5**	200	0.998	**31.5**	3	**65.5**	3	**72.0**	3	**63.5**

62	51.45	**70.5**	125.00	4	5	**44.5**	0	**37.5**	2	**52.5**	200	0.998	**31.5**	3	**65.5**	3	**72.0**	3	**63.5**
147	52.10	**72**	33.33	9	3	**79.0**	0	**37.5**	3	**80.5**	10275	0.886	**73.0**	2	**38.5**	2	**39.0**	1	**10.0**
102	52.40	**73**	20.00	5	1	**82.0**	0	**37.5**	2	**52.5**	15200	0.832	**76.0**	1	**16.5**	3	**72.0**	2	**29.5**
68	52.95	**74**	100.00	2	2	**55.5**	0	**37.5**	2	**52.5**	900	0.990	**50.0**	3	**65.5**	2	**39.0**	3	**63.5**
47	53.15	**75**	150.00	2	3	**34.0**	0	**37.5**	3	**80.5**	0	1.000	**11.5**	3	**65.5**	4	**83.5**	3	**63.5**
55	54.05	**76**	33.33	3	1	**79.0**	1	**6.0**	2	**52.5**	60225	0.334	**84.0**	1	**16.5**	2	**39.0**	3	**63.5**
65	54.75	**77**	100.00	2	2	**55.5**	0	**37.5**	2	**52.5**	2250	0.975	**59.0**	3	**65.5**	2	**39.0**	3	**63.5**
114	56.05	**78**	66.67	3	2	**69.5**	0	**37.5**	2	**52.5**	10225	0.887	**72.0**	2	**38.5**	2	**39.0**	3	**63.5**
174	56.75	**79**	33.33	3	1	**79.0**	1	**6.0**	2	**52.5**	33760	0.626	**81.0**	1	**16.5**	3	**72.0**	3	**63.5**
73	56.90	**80**	40.00	5	2	**76.0**	0	**37.5**	2	**52.5**	18025	0.801	**77.0**	3	**65.5**	3	**72.0**	2	**29.5**
17	61.20	**81**	200.00	2	4	**18.0**	0	**37.5**	3	**80.5**	24475	0.729	**79.0**	2	**38.5**	3	**72.0**	3	**63.5**
143	61.25	**82**	66.67	3	2	**69.5**	0	**37.5**	2	**52.5**	6300	0.930	**68.0**	3	**65.5**	3	**72.0**	3	**63.5**
120	62.40	**83**	0.00	4	0	**84.0**	0	**37.5**	2	**52.5**	56200	0.378	**83.0**	3	**65.5**	2	**39.0**	3	**63.5**
87	68.75	**84**	50.00	2	1	**74.5**	0	**37.5**	3	**80.5**	12250	0.864	**75.0**	3	**65.5**	3	**72.0**	3	**63.5**
162	72.85	**85**	0.00	3	0	**84.0**	0	**37.5**	3	**80.5**	90375	0.000	**85.0**	4	**65.5**	4	**83.5**	3	**63.5**

Transferability of the HSVI

The particular results of the Household Social Vulnerability Index presented here have been discussed elsewhere (Vincent, 2007a, b). What is of relevance to this paper is the extent to which this index is conceptually transferable to other circumstances. The contextual nature of vulnerability and the difficulties of validation provide challenges to the development of robust indicators. However, since the effectiveness of adaptation actions is unlikely to be seen until exposure to a hazard in the future, indicators of vulnerability are required in order to empirically assess the effectiveness of adaptation interventions.

Elsewhere the scale of analysis has been highlighted as critical in affecting the choice of indicators (Vincent, 2007a). Theory-driven indices such as this go some way to addressing this, as the theoretical driving forces of vulnerability are similar, even if the specific composite sub-indices, indicators and their weighting needs to be modified according to context. Indicator selection also requires a trade-off between specificity or transferability and accuracy or certainty. But whilst this is important in considering the application of indicators across spatial scales, it is of less concern in their temporal use in one location. Similarly the results of this index make no attempt to assess absolute vulnerability, recognising that is a dynamic state, resulting from the interaction of a number of driving forces in any one place and at any one time. Thus the index has potential to both identify the most vulnerable households to target for adaptation interventions, as well as then showing their shift in vulnerability relative to other households post-intervention. However, since it shows relative vulnerability and not absolute, it would not be appropriate to chart change in vulnerability status of interventions that target all households in any one location.

Conclusion

The paper has outlined a theoretically-driven index of social vulnerability to climate change. Based on the sustainable livelihoods framework, the household social

vulnerability index is formed from the weighted average of five composite sub-indices: financial capital (20%); human capital (20%); social capital (20%); natural capital (20%); and physical capital (20%). Whilst in this paper the index has been presented with indicators and weightings as appropriate to one village in Limpopo province, South Africa, the theoretical nature of the index means that it is appropriate for modification and use in other rural settings. This fills an important policy and practical need in terms of the growing field of climate change adaptation. Since the effectiveness of adaptations are only realised after exposure to the hazard in question, development agencies, funders and NGOs need a way of both targeting their interventions, and then monitoring and evaluating their success. By using the HSVI to rank households at the beginning of the intervention, the most vulnerable can be targeted. And then re-applying it during the intervention and afterwards shows how the relative vulnerability of targeted households changes relative to others in the location.

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