Food System Scenarios:

Exploring Global/Local Linkages

Working Paper

Thomas E. Downing and Gina Ziervogel

SEI STOCKHOLM ENVIRONMENT INSTITUTE

Food System Scenarios: Exploring Global/Local Linkages

Working Paper

Thomas E. Downing and Gina Ziervogel

for the Poverty and Vulnerability Programme
Stockholm Environment Institute (SEI)

February 2005

SEI STOCKHOLM ENVIRONMENT INSTITUTE

Stockholm Environment Institute
Lilla Nygatan 1
Box 2142
SE-103 14 Stockholm
Tel: +46 8 412 1400
Fax: +46 8 723 0348
E-mail: postmaster@sei.se
Web: www.sei.se

Communications Director: Arno Rosemarin
Publications Manager: Erik Willis
Layout: Lisetta Tripodi
Web Access: Howard Cambridge
Cover photo: Gina Ziervogel

Copyright 2005 by the Stockholm Environment Institute
This publication may be reproduced in whole or in part and in any form for educational or non-profit purposes, without special permission from the copyright holder(s) provided acknowledgement of the source is made. No use of this publication may be made for resale or other commercial purpose, without the written permission of the copyright holder(s).

ISBN 91 975238 1 X

Contents

Tables

Figures

Introduction

The first round of assessments on global change tended to adopt an environmental determinism view of the future—population growth was projected, environmental degradation was forecast. A simple version of this was expressed as the IPAT identity: Impact = Population x Affluence x Technology. The first generation of climate impact assessment was led by scenarios of climate change projected over the course of a century. In contrast, over the past decade and longer, analysts of the interactions of environment and human behaviour have recognised the indeterminism of complex systems, for instance in the notion of multiple equilibriums that are sensitive to threshold-crossing events. This realisation gave impetus to the use of scenarios to express future stories for various purposes.

At present there are two dominant modes of scenario construction. The most widely known and visible ones are constructed at a generalised and often global level. They are developed by relatively small teams, usually experts chosen to represent different sectors. This 'top-down' approach provides a consistent framework for a variety of studies. Common examples are the IPCC SRES (Nakicenovic and Swart, 2000) and in the UK, the Foresight panel. The other mode builds 'bottom up' scenarios that tend to focus on local-level dynamics with a base in participatory and stakeholder methods. It is considerably more difficult to construct a participatory, representative process around global scenarios. The two modes should not be seen as opposites, nor do they necessarily cohere.

The aim of this working paper is to explore scenario methodologies and seek to define a more integrated scenario approach that builds on livelihood systems as a scale for scenarios that integrates local livelihoods dimensions with national or global level stressors. While we develop our ideas in the context of food security and global climate change, the needs are similar in other sectors.

Four challenges must be met to make substantial progress in framing and using scenarios:

1. The global scenarios should encompass sensitivity to environmental change, socio-economic vulnerability and adaptive capacity. Many global food system scenarios are derived for specialised purposes, such as estimating global market prices. Often they do not adequately frame food insecurity in its several dimensions. For instance, the IPCC's SRES scenarios were developed to bracket global greenhouse gas emissions. While they fulfil this aim, they are not adequate to understand climate vulnerability—even in the 'poorest' scenario per capita GDP in developing countries reaches the present OECD level by the time climate impacts become significant.

2. Vulnerability is a multi-scale phenomenon, and a consistent treatment from household to province to nation to world is required. The linkages are essentially related to processes and pathways rather than downscaled parameters or upscaled aggregation.

3. At the intermediate scale, where livelihood groups and systems operate, linkages can be drawn between the global and local, and between descriptions of conditions to analyses of processes. Livelihood analysis has become quite common in development planning, but few if any examples of longer term food security scenarios explicitly relate to livelihoods.

4. Scenarios are intended to provide insight and this is strengthened through a participatory process. So, methods of stakeholder participation are essential, and need to be matched to the level of analysis.

Figure 1 sketches, in a primitive way, the participatory methods that may be used to frame and build scenarios at different scales. For example, at the household level participation can identify the most vulnerable (Hoddinott 1999). At a larger scale, role playing and visioning exercises might engage representatives of livelihood groups (Ziervogel, 2004). At the national and global scales, however, there is a lack of adequate participatory methods. The absence of appropriate methods underscores the methodological and socio-political tensions between stakeholders and issues at different administrative levels.

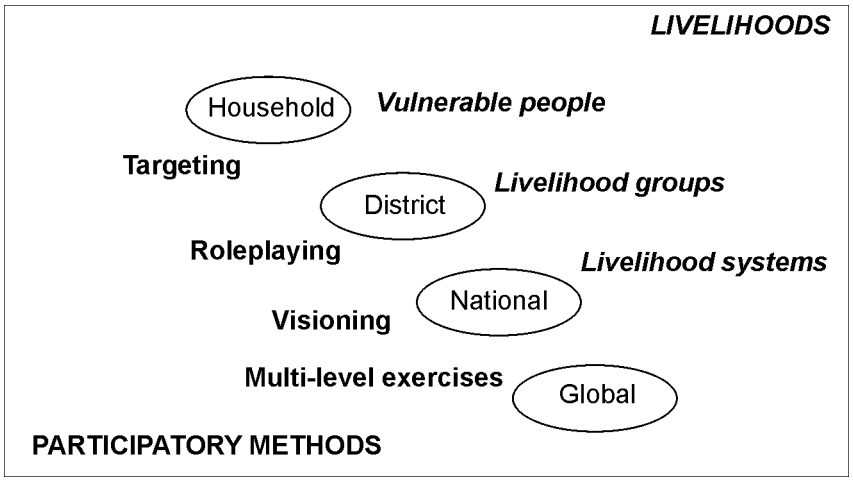


Figure 1 Sketching participatory methods for exploring future livelihoods

The approach taken in this paper builds on an understanding of livelihoods. Livelihoods can be considered as the combined activities and available social and physical assets that contribute to the households' existence (Carney, 1998). Each individual has their own means of securing a livelihood and together the individuals make up the households' packages of livelihood assets and strategies. Similar characteristics and activities in household livelihoods can be grouped together to form livelihood typologies. These help focus on an intermediate system level that draws from the local but has a unit of analysis greater than local but less than global. This 'intermediate' livelihood system is a useful link for developing scenarios that draw on both global and local drivers. These livelihood systems can describe large, cross-boundary, geographical areas that are a real mid-point between a 'local' and 'national/global'. In some instances a livelihood system may be contained in a small geographical area and in other instances they may cross national boundaries. The livelihood system may also be compared to the food economy zone or the agro-ecological zone that describe system characteristics rather than geographical boundaries. For example, the household economy analysis that builds on the food economy zone, monitors the predominant food economy system characteristics relating to production, consumption and change of food items (Seaman, J, 2000; Seaman et al, 2000).

This working paper illustrates ways in which these challenges can be met. We start with a summary of existing global food system scenarios. One of the widely available efforts is the suite of four scenarios developed by the Global Scenarios Group[1]. We illustrate how this suite of scenarios might be applied in the context of food security in South Africa and India. The

1 The Global Scenarios Group was established in 1995 at Stockholm Environment Institute, Boston, to develop scenarios that focus on transition to a sustainable equitable future (http://www.gsg.org/). The data for these scenarios and developing alternatives can be found in the PoleStar System that was developed by the GSG.

characteristics of these countries are not seen as the same as the regional characteristics as given in PoleStar and so the methods used in this paper illustrate how regional scenarios might be used to help develop national scenarios. Although this method has limitations, it helps to examine the opportunity and limitations of using global scenarios to examine livelihood systems. The link between global and national is not a key focus in this paper. However, this relationship is dealt with by examining how continental scale scenarios might be downscaled to the national level (which therefore contain elements of global scenarios). It is the addition of the livelihood system that is the focal scalar element in this paper.

We then shift focus to explore a livelihood approach to 'bottom up' scenarios. Examples from Africa are reported, although these are based on relatively rapid processes with researchers in different workshops. We conclude with a discussion of the gaps between common global scenarios and the local context of food security. Suggestions for further scenario development include expanding the range of participatory methods.

Developing Food System Scenarios

Scenarios are possible futures. The future is unknown and so it is necessary to consider many alternatives of what the future might be, taking account of the full range of imaginable futures. From this population of possible (or plausible) futures, a number of outcomes can be chosen and combined to produce coherent, consistent scenarios that can help to envision possible futures.

A common approach to producing scenarios is to represent a 'best guess', assuming that the world will continue the way it is going at present. Then, alternatives can show changing social, economic, political and environmental contexts. This approach allows expected impacts from the reference case to be compared to those from scenarios of more concerted action (optimistic visions) or of deteriorating environmental and economic conditions (increasing the reference vulnerability). For instance, trends in population growth are often related to female education and the distribution of per capita income, based on current experience. These can then be projected into the future with some bands of uncertainty to produce global scenarios of world and regional population (Lutz, Sanderson et al., 2004). This empirical approach works reasonably well where the underlying relationships are well understood and robust over time. Such is not the case for the linkages between climate change, vulnerable food systems and regional socio-economic development.

A selection of scenarios that relate to future vulnerability and food security issues are used to illustrate the type of scenarios that are presently available (Table 1). Drawing on these existing scenarios highlights how new scenarios might inform poverty and food security interventions.

Table 1 illustrates the many ways in which scenarios can be produced and used. The different measures used to construct the scenarios depend on the aim of the scenarios and the data available for use. For example, the Great Transition scenarios (2) use market forces and policy reforms as a way of determining and differentiating between scenarios or futures. In comparison, the Scenarios of Sustainability (1) choose issues of equity and access to education as measures for defining sustainable future food systems. Part of the reason for choosing different measures might be the intended use of the scenarios. Another practical constraint

Table 1 Comparison of different food system scenarios

Scenario name	Authors/Origin	Type of scenarios/ storylines	Coverage/ regions	Timescale/ projection	Measures	Relevance for food systems
1. Scenarios of sustainability	Rothman and Coppock (1996) World Resources Institute	Sustainable development	Focus on southern Africa	2050	Access to education Greater equity End to absolute poverty Harmonious relationship between mankind and nature	Focus on sustainable food systems
2. Great transition	Global Scenario Group (Raskin et al., 2002)	Conventional worlds Barbarization Great Transitions	Global	2050 (and 2025)	Market forces Policy reforms Great transitions – value shifts Fortress world (peace, freedom, development, climate, ecosystems, water stress)	Food demand and diet trends are predicted for different scenarios for poor and rich regions
3. Socio-economic scenarios	UNDP-GEF (2001) Based on SRES	World markets Provincial enterprise Global sustainability Local stewardship	Global-regional	2100	Economic capacity Human and civic resources Environmental capacity	Food sensitivity based on cereal production/ area and animal protein consumption/ capita
4. 2020 Global food outlook	IFPRI (Rosegrant et al., 2001)	Baseline Optimistic Pessimistic	Global	2020	Low/high population growth Higher livestock productivity via lower feeding ratios Full trade liberalisation	Food security determined by predicting no. of malnourished children under 5
5. Alternative futures for child poverty in the U.S.	Center on Hunger and Policy, Tufts	Child poverty: 2 trends	U.S.A.	2010	Based on 1959-1992 trends of child poverty and area of residence	Focus social policies
6. Land use and land cover change scenarios	IPCC (Fisher et al. 1995, 2002) (Vogel, 1998)	CO_2, SO_2, S-Deposition, N-Deposition, Ground-Level O_3	Global, focus on Europe	2010, 2050, 2100	Sensitive to agricultural productivity and so demand depends on which scenarios are used	Asks how land can be better managed to reduce vulnerability to climate change and facilitate adaptation and mitigation
7. India water partnership	Global Water Partnership	Various stakeholder visions of supply and demand of water	India	2025	Implications of scenarios for water scarcity, food security, livelihood security, water quality and public health	How water demand and supply might affect food security

might be the type of data available and the level of detail needed in the data. The Scenarios of Sustainability are produced at the regional level and so require more locally specific data whereas the Great Transition scenarios are produced for the global level and use data that is aggregated to a continental level. The aims of these two scenarios are also different; their relevance for food security research and interventions also are different. Scenarios aimed at highlighting issues of access to education and sustainable development at the national level have different implications to those aimed at establishing the impact of sustainable versus barbarian futures on global resources. The aim of building the scenarios should therefore be clear from the start, as it will help scenarios to be used more effectively.

A first set of scenarios might also be used as stepping stones to further research. For example, the IFPRI food scenarios (4) have been developed further to consider food and water scenarios until 2025. The food and water scenarios have been developed to help assess possible policy responses to the threat of scarcity (Rosegrant, Cai et al., 2002). Similarly, aspects of scenarios may be developed further for specific needs that arise out of the initial scenario work.

At the same time as understanding the constraints and aim of scenarios, it is important to be critical of the data used and the way scenarios have been constructed. The quality of data determines the quality of the output. Data that capture one scale might become insignificant when compared to data at another scale. For example, national scenarios that integrate data on household access to capital with district access to capital might not be readily available. Integrating these different scales of analysis could lead to confusion as almost inevitably one scale will dominate the other in the scenario. Scenarios that focus on certain types of data might present a biased view of the situation and that in turn might bias future policy and development work. It is therefore critical that scenarios be transparent in their data analysis methods and techniques for presenting and explaining the outcomes. It is not clear that a code of best practice exists for reporting scenario methods and results in ways that clearly demarcate the intended uses and limitations.

This sample of food system scenarios can be grouped in a typology based on the geographic scale and the socio-economic groupings (Table 2). Most of the scenarios are on the global scale with an integrated, systemic view or a narrower concern with a specific sector. Some do not attempt a global integration and focus on a national level. Only one approach appears to take a livelihood focus, although this is more generic than local. And only one appears to be geographically fixed at a local level, albeit for a specific issue. Of course, most of the scenarios cover more than one scale and draw implications at a finer level of socio-economic concern than indicated in this simple typology. Nevertheless, the lack of local-livelihood scenarios is apparent (at least in the literature that we have been able to draw upon and possibly in practice).

Table 2 A typology of food system scenarios based on socio-economic and geographic scales

	Global	National	Local
Livelihood		India water partnership	
Sectoral	Global food outlook	India water partnership	Land use change
Systemic	Great transision	Scenarios of sustainability	
	Socio-economic scenarios	Child poverty futures	

What are the strengths and weaknesses of the existing approaches to producing food security scenarios if the goal is to better understand future scenarios of vulnerability and food security? The specifics of these scenarios are mentioned in Table 1. We seek to work toward a protocol for how future food security scenarios might best contribute to developing appropriate interventions or analyses (and offer further thoughts in the conclusion).

It is well established that food security depends not only on availability of food but on access to food, quality and a number of other factors. The existing scenarios tend to focus more on supply and demand issues rather than on livelihood security and local capacity. There are not many food systems scenarios that concentrate on the future availability and access of food to various groups which results in a narrow view of future food security being assessed.

The creative work of national scenarios could be built on and used to present case studies that link local and national research into global level scenarios. This is not well captured at present as global scenarios lack the dynamics of national level scenarios, a scale that is paramount when trying to influence local realisations of food security. Equally, the global perspective is necessary to locate the local variability so that understandings of systems are not simply scaled up or scaled down but are appreciated within the dynamics of the appropriate scale and the hierarchy of levels (Cash and Moser 2000; Downing, Butterfield et al. 2001; Stephen and Downing 2001). Questions that could focus future food scenario developments are, who is the target audience, what tools are available for producing scenarios, what data is already available and how can future food security scenarios be developed so that they are as holistic and useful as possible?

One aspect that might be more thoroughly considered is the influence of livelihood characteristics on food security scenarios. Livelihood approaches have gained prominence in the last decade as a means for integrating myriad facets of rural livelihoods that are necessary to understand in order to address vulnerability (Carney, 1998). However, there are not many examples of livelihood scenarios. This could be attributed to the fact that livelihoods research focuses on the local scale, which makes broader generalisation difficult or because it is a relatively new approach that has not yet adopted a scenario perspective. Such issues and the type of data input into scenarios are critical to consider, as they help to evaluate the use and quality of the scenarios.

From Global Scenarios to Local Food Security

The Global Scenario Group (GSG) scenarios are based on a two-tier hierarchy. At the first level, Conventional Worlds, Barbarization and Great Transitions represent fundamentally different social visions. At the second level, each of these classes has two variants. The GSG's analysis has focused on the six scenarios described in Table 3. The GSG research includes analysis of the driving forces, critical uncertainties and stresses on social and environmental systems for each scenario. It quantifies economic, social, resource and environmental patterns for 11 world regions both currently and for each scenario. The research identifies the policies, values, institutions and life-styles required for a sustainable future. The PoleStar software developed by the SEI provides a comprehensive data base and accounting framework for developing alternative scenarios (see www.gsg.org).

Table 3 An overview of the social visions and variants of the Global Scenario Group scenarios

	Conventional Worlds	Barbarization	Great Transitions
Main narratives	These scenarios envision the global system of the twenty-first century evolving without major surprises, sharp discontinuities or fundamental transformations in the basis for human civilization. Dominant values and institutions shape the future, the world economy grows rapidly and developing countries gradually converge toward the norms set by highly industrial countries	These scenarios envision the grim possibility that the social, economic and moral underpinnings of civilization deteriorate, as emerging problems overwhelm the coping capacity of both markets and policy reforms.	These scenarios explore visionary solutions to the sustainability challenge, including new socioeconomic arrangements and fundamental changes in values. They depict a transition to a society that preserves natural systems, provides high levels of welfare through material sufficiency and equitable distribution, and enjoys a strong sense of social solidarity. Population levels are stabilized at moderate levels and material flows through the economy are radically reduced through lower consumerism and massive use of green technologies.
Variants	**Market Forces**	**Breakdown**	**Eco-Communalism**
	This variant incorporates mid-range population and development projections, and typical technological change assumptions. The problem of resolving the social and environmental stress arising from global population and economic growth is left to the self-correcting logic of competitive markets.	In this variant, crises combine and spin out of control, leading to unbridled conflict, institutional disintegration and economic collapse.	The Eco-Communalism variant incorporates the green vision of bio-regionalism, localism, face-to-face democracy, small technology and economic autarky.
	Policy Reform	**Fortress World**	**Great transition**
	Policy Reform adds strong, comprehensive and coordinated government action, as called for in many policy-oriented discussions of sustainability, to achieve greater social equity and environmental protection. The political will evolves for strengthening management systems and rapidly diffusing environmentally-friendly technology, in the context of proactive pursuit of sustainability as a strategic priority.	Fortress World features an authoritarian response to the threat of breakdown. Ensconced in protected enclaves, elites safeguard their privilege by controlling an impoverished majority and managing critical natural resources, while outside the fortress there is repression, environmental destruction and misery.	This variant shares some of the goals of the Eco-Communalism scenarios, but would seek to change the character of the urban, industrial situation rather than to replace it, to build a more humane and equitable global civilization rather than retreat into localism. The New Sustainability Paradigm is the focus of Great Transition.

Note: The breakdown and eco-communalism scenarios are not evaluated in the two examples of food security in this working paper.

In the Polestar system 'hunger' is based on the FAO estimates of the national incidence of chronic undernutrition for developing countries and countries in transition (Figure 2). For the US, the incidence of food insecurity was used. For all other countries, estimates are based on income distribution. In all the scenarios, hunger is determined by changes in income, income distribution and population. The Policy Reform scenario meets the sustainability goal of reducing hunger by one-half between 1995 and 2025 and by one-half again between 2025 and 2050.

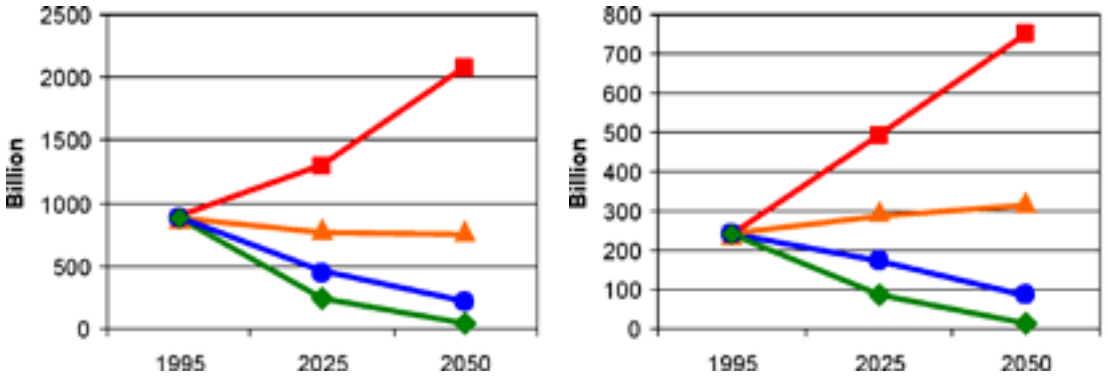


Figure 2 Hunger indicator from PoleStar at the global level (left) and for Africa (right)

Key:

If we accept that the Global Scenario Group scenarios are a worthwhile point of departure, what are the requirements to relate these broad-brush visions of the global system to local food security? The methodology we explored involves the following steps:

1. Select a food security approach and set of indicators that are common in national planning. For South Africa we use an approach by the Department of Agriculture (NDA, 2002). In India, the MS Swaminathan Research Foundation (2001) carried out a rural food insecurity mapping exercise with the World Food Programme (updated in 2004).
2. Identify and extract from PoleStar a set of indicators that are similar to or relevant to the national food security indicators.
3. Downscale the PoleStar geographic area from Africa to South Africa and from South Asia to India.
4. Map the relationship between the PoleStar indicators to the national food security indicators.
5. Estimate the impact on the national food security indicators of relative changes in the PoleStar scenario indicators.
6. Explore the implications of different aggregation methods.
7. Relate the national scenarios to the state or district level, and more local scales if possible.

RURAL FOOD INSECURITY IN INDIA

The starting point for the assessment of future food security in India is the baseline of rural food insecurity in India compiled by the MS Swaminathan Research Foundation (M.S. Swaminathan Research Foundation 2001, 2002, 2004). The atlas compiles a range of indicators at the state level, organised into three categories:

- Food availability
  - *Deficit between consumption and production*
  - Instability in cereal production
  - *Environmental sustainability index (wastelands)*
  - Population affected by floods and cyclones
  - Area affected by drought

- Food access
  - Calorie intake of lowest decile
  - Population consuming less than 1890 kcal/day
  - *Population below poverty line*
  - *Population dependent on agricultural labour income*
  - *Rural infrastructure index (roads)*
  - *Rural infrastructure index (electricity)*
  - *Female sex ratio for juveniles*
  - *Female illiteracy*
  - *Scheduled populations*
- Food absorption
  - Life expectancy at age 1
  - Population with chronic energy deficiency
  - Severely stunted children under 5
  - Severely wasted children under 5
  - *Infant mortality rate*
  - *Health infrastructure index (hospitals)*
  - *Health infrastructure index (water)*

From this list of indicators, the 12 in italics were chosen as the most informative with complete data. These indicators were mapped by the MSSRF based on a simple, unweighted aggregation of the standardised indicators across all of the indicators (Figure 3). The result shows the relatively higher vulnerability of the northern tier of semi-arid and sub-humid states.

Figure 3 Rural food insecurity in India based on an aggregate index

The three dimensions of food insecurity in the atlas can be used to chart clusters of the states. Rather than rank overall vulnerability, this approach decomposes vulnerability into the main attributes—food availability (based on production), food access (the economic and demographic aspects of food demand), and food absorption (or the nutritional aspects of food insecurity). This approach is shown in Figure 4. Kerala, Himachal Pradesh and Punjab are relatively well off—with higher scores on all three dimensions. Gujarat and Bihar are the most vulnerable, but with striking differences in food access. A cluster of states are in the middle, possibly improving from historic vulnerability but not as yet achieving satisfactory levels of food security.

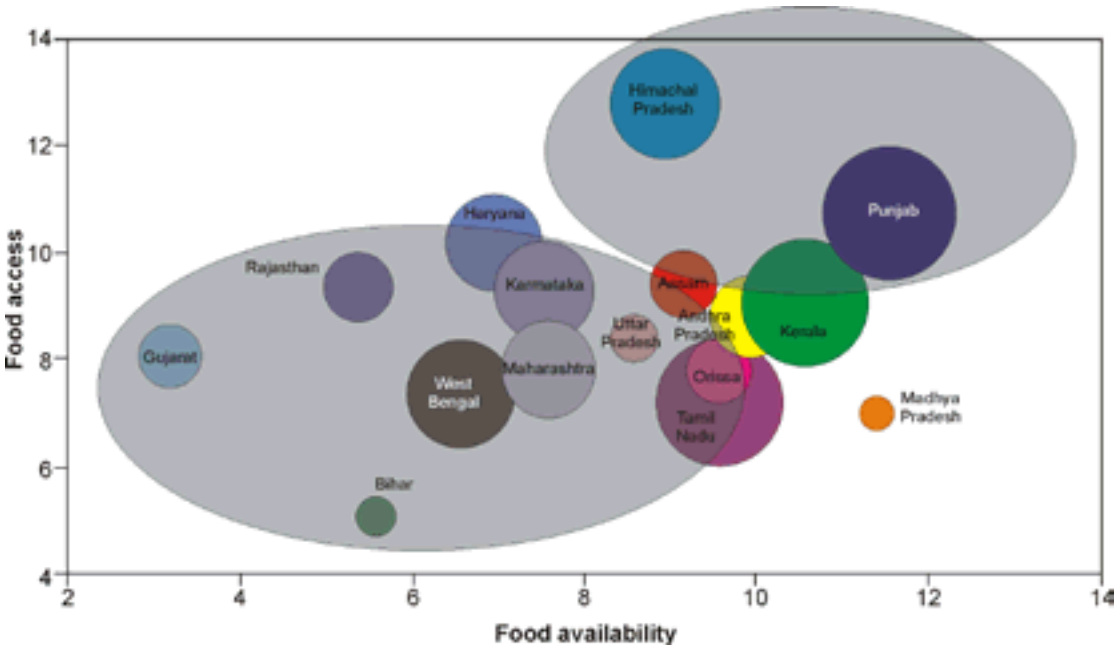


Figure 4 Clusters of vulnerability in India. Food absorption (a range of nutritional indicators) is shown in the width of the bubbles for each state

Given this baseline of present vulnerability, the next step is to match these indicators (using the smaller set of 12) to the PoleStar global scenarios. Conveniently, the PoleStar data base includes a regional analysis of South Asia. For lack of any better insight, we assume that a change in the PoleStar South Asia indicators is equivalent to a change in indicators for India. That is, we ignore the relatively minor differences between a picture of South Asia and a scenario downscaled to India. Note that in the African example, this assumption does not hold—it is readily apparent that South Africa is significantly richer than the rest of Africa and along with other southern African countries has high prevalence rates of HIV/AIDS (UNAIDS, 2004).

The PoleStar variables that relate to food security are both general (e.g., GDP per capita) and specific (various indicators of poverty and hunger). The variables chosen for this analysis are shown in Table 4.

One salient observation is that the PoleStar variables do not adequately cover all of the food insecurity indicators. Thus, the scheduled populations, female sex ratio, access to roads, and electricity indicators have only one or two relevant variables in the PoleStar data base. Conversely, there are quite a few agricultural production variables that might be relevant.

This mix of variables needs to be related to each of the MSSRF food insecurity indices, as shown in Table 4. The entry point is a matrix that shows the extent to which a PoleStar variable has an influence on each of the food insecurity indicators. For example, GDP per capita is taken to be a moderate to strong influence on 7 of the 12 food insecurity indicators. In each case the relationship is negative—that is an increase in GDP per capita leads to a decrease in vulnerability. Or the percentage of the population below the hunger line is a more specific condition (affecting only two indicators: poverty and infant). And in each case the relationship is positive—an increase in hunger is a high correlate with an increase in vulnerability.

Table 4 Matrix of the relationship between PoleStar variables and food insecurity indicators for India

	India food insecurity indicators											
PoleStar Indicators	**Cons/Prod**	**Wastelands**	**Poverty**	**Scheduled**	**Illiteracy**	**Sex ratio**	**Roads**	**Electricity**	**Ag Labour**	**Infant**	**Hospital**	**Water**
Population	+										+++	
Urban Fraction	+	---				--					--	
GDP per cap, growth rate												
GDP per cap [PPP$/cap]	---	---	---		--				--			---
Agricultural Value Added per cap	-								---		---	
Services Value Added [10^9PPP$]									---			
Hunger Line, $/cap												
Gini Coefficient					++					++		
Lowest Quintile			---									
National Equity			---	-						++	++	
Hunger%			++							++		
Income of Poor [$/cap]			---		---	---		---		---	--	
Calorie Intake [Cal/cap/cay]	---											
Increase in Irrigated Crop Intensity	--											
Increase in Irrigated Yields	--											
Irrigated Yield	--											
Increase in Irrigated Area	--											
Increase in Rainfed Crop Intensity	--											
Increase in Rainfed Yields	--											
Rainfed Yield	--											
Wheat & Coarse Grains: Rainfed Yield	--											
Wheat & Coarse Grains: Irrigated Yield	--											
Rice: Rainfed Yield	--											
Rice: Irrigated Yield	--											
Wheat & Coarse Grains: Total Fertiliser Input Intensity	--											
Rice: Total Fertiliser Input Intensity	--											
Electricity Fuel Use [PJ]								---				
Freight Intensity [t-km/PPP$GDP]		++					---					
Water Withdrawals per cap												+++
Water Use/Resource Available												+++

Key:
+++ = strong politive influence of PoleStar indicator on food insecurity indicator
--- = strong negative influence of PoleStar indicator on food insecurity indicator

The next step is to calculate the numerical strength of this influence. This has two steps. The first is a value for the elasticity of the link—the degree to which a change in the PoleStar variable would produce a change (an increase or decrease) in the food insecurity indicator. Note that the food insecurity indicators have all been transformed so that 100 = high vulnerability. The second estimate is the relative weight of the link in compiling the total change in the food

insecurity index. The changes implied by the elasticities and weights are combined to produce an estimate of each indicator's value for each GSG scenario.

We can restate this mathematical treatment in simpler terms: the global scenario implies changes in food insecurity indicators in India. The direction and nature of the changes depend on the effect of several driving forces (such as GDP per capita and the distribution of income) on the food insecurity indicators.

The final step in this exploration of downscaling global scenarios is to relate the overall scores for India to the level of the state. Conceivably, this would involve consideration of the distinctions in each state at present (already part of the MSSRF assessment) and how food insecurity might progress along different lines in each state. Thus, it might be that limits to food productivity and irrigation are likely to affect some states sooner than others. In the present exercise, the simpler approach was to assume that the relative food insecurity of each state remains as at present. That is, the values of the indicators in the scenarios (2025 in the example) at the level of the state are proportional to their difference from the present average for all of the states. This measure is done at the level of each food insecurity indicator, so it is possible that the overall ranking of states might be different in the future depending on the components of vulnerability.

Note that this example is a subjective estimate by the authors. More experts could be drawn in, and wide consultation with stakeholders might be useful. However, it is likely to be a somewhat arbitrary exercise in the final numbers. Hopefully the overall change will capture the differences in the global scenarios and their implications for food insecurity in India.

The results shown in Figure 5 are for 2025. The PoleStar database includes projections for 2050 as well. They indicate that in each of the four GSG scenarios explored here, food security would improve (Figure 5). The present status (the base case) for almost all of the indicators is higher (more vulnerable) than any of the scenarios. However, there are quite different levels of improvement for some of the scenarios, and the profile of changes may be different. For example, the range of scenario results is quite large for poverty, illiteracy and electricity. Conversely, the base case and all of the scenarios are quite similar for the balance of consumption and production, scheduled populations, roads, infant mortality, hospitals and water. These variables are thus not as relevant in distinguishing the scenarios from each other, or from the present.

The results at the national level can be captured by averaging all of the indicators. This is a simple approach; below we comment on other aggregation procedures. The average score across all of the indicators of present national food security is 52. The Great Transitions scenario scores the lowest (best) with an average score of 29, compared to the 'worst case' scenario of the Fortress World, with 40 (but still better than the present).

At the district level, food security improves in the future, but is somewhat different for each scenario. Profiles of food insecurity show the results for two states (Figure 6). Bihar is the most vulnerable state in India, with Kerala among the more food secure states. For Bihar, the Fortress World scenario is not dissimilar to the present, although with some improvement in electricity provision and dependence on agricultural labour. In contrast, the Great Transitions scenario is substantially better for many indicators. Kerala has two extreme values—very low infant mortality but quite high water scarcity. Neither of these change much in the scenarios, in contrast to improving conditions for the female sex ratio, electricity and agricultural labour.

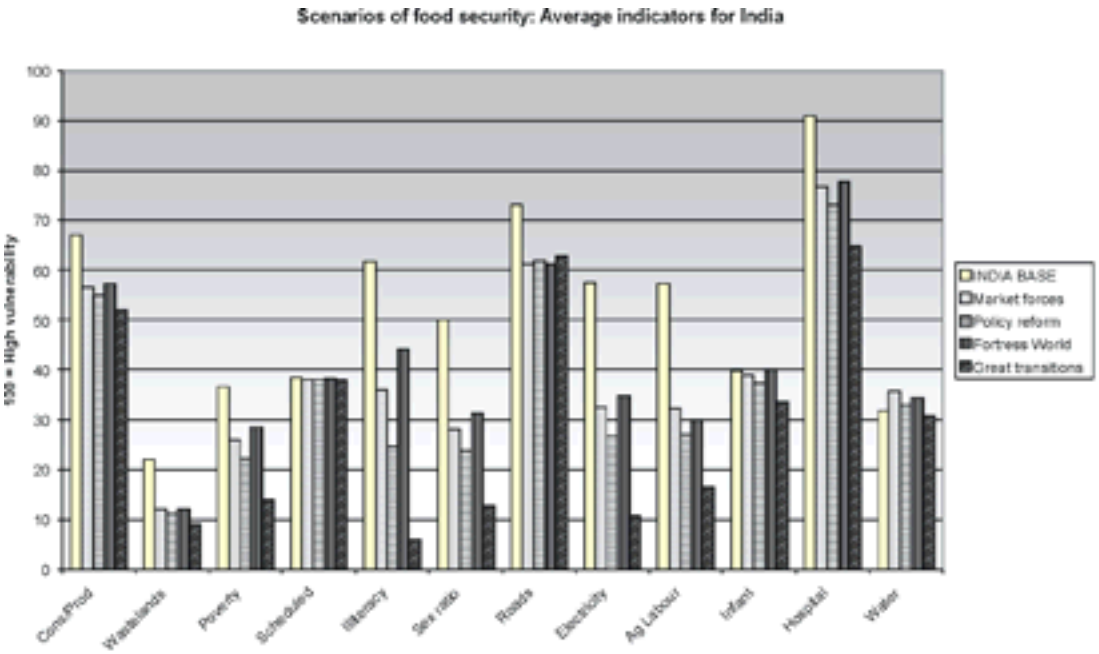


Figure 5 Scenarios of future food insecurity for India in 2025

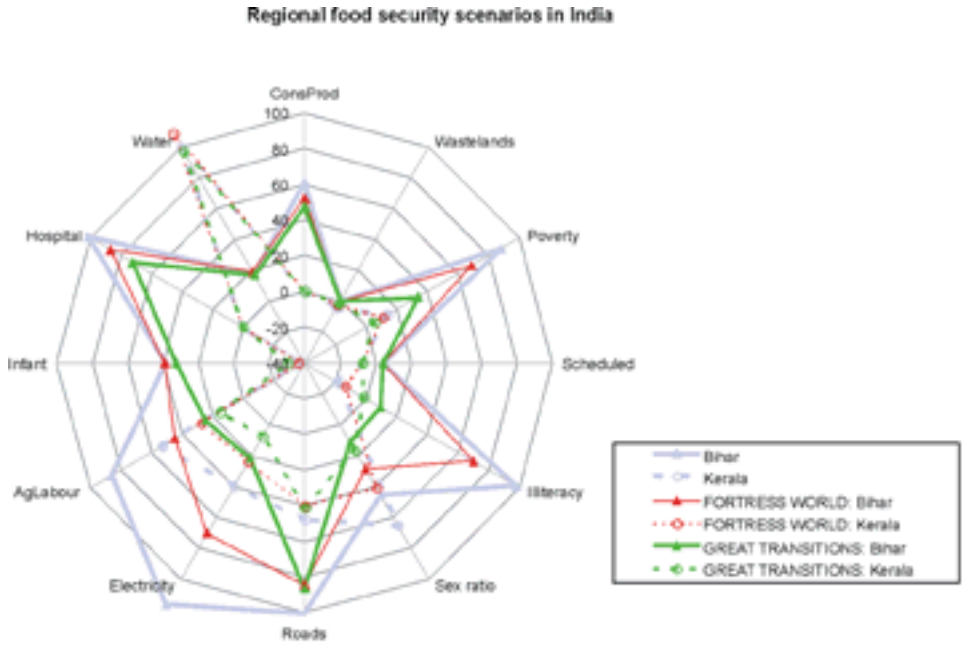


Figure 6 Future food insecurity in selected states of India

Next we show similar results for South Africa, drawing overall conclusions regarding the downscaling exercise in the summary to this section.

FOOD SECURITY IN SOUTH AFRICA

South Africa has changed dramatically in the past two decades, since the abolishment of apartheid. This has prompted investigation into potential scenarios of the future, which have focused on the economic (Berger and Godsell, 1989) and political futures (Adam and Moodley, 1993; Sunter, 1987) that might unfold in South Africa. There has been little focus on what this might mean for the future livelihood and food security of vulnerable groups. The changing political environment has implications for a variety of sectors that impact livelihoods, including agriculture. The impacts of the environment, including political, physical and economic factors on food security should be a priority, especially given the recent food crisis in the region in 2002 (Vogel and Smith, 2002; Mano, Isaacson et al., 2003). The nature of food security is as much about access to food as production, which requires an analysis of local level institutions. For this to be assessed it is necessary to consider the many factors impacting food security at a variety of scales that reflect livelihood dynamics where possible.

The starting point for the assessment of future food security in South Africa is a food security framework developed by the National Department of Agriculture (Table 5) (NDA, 2002b). Four categories of food security are shown, each with two indicators. The typology and choice of indicators is similar as for India, reflecting the common framework of vulnerability mapping developed by the World Food Programme, Food and Agriculture Organisation, famine early warning systems and others.

Table 5 Food security framework for South Africa

Categories	Indicators	
Food access		
Also effective demand: ability of nation and its households to acquire sufficient food on sustainable basis. It addresses issues of purchasing power and consumption behaviour.	1 2	Unemployment GDP per capita
Food availability		
Effective or continuous supply of food at both national and household level. It is affected by input and output market condition, as well as production capabilities of the agricultural sector.	3 4	Maize consumption per capita Measure of production
Reliability of food		
Utilisation and consumption of safe and nutritious food.	5 6	HIV infection rates Infant mortality
Food distribution		
Equitable provision of food to points of demand at the right time and place. This spatial/time aspect of food security relates to the fact that a country might be food secure at the national level, but still have regional pockets of food insecurity, at various periods of the agricultural cycle.	7 8	Roads Primary health centres

Data for each of the indicators at the national and provincial level was collated from the Statistics South Africa (StatsSA), Department of Agriculture, state of the environment reports, and household surveys (NDA, 2002a). The distribution of food security varies between the provinces. The data are shown in Table 6 and graphically represented in Figure 7. Maize consumption is high in every province, but production varies with high production in the Northern Cape and low production in five provinces. Perhaps the most striking indicator is the incidence of HIV infection—over 30% in three provinces.

Table 6 Indicators of food security in South Africa

	Food access		Food availability		Reliability of		Food distribution		
	Unemployment (%)	GDP per capita (PPP$)	Maize consumption per capita	Maize production (t/ha)	HIV+	Infant mortality per 1000	Road density km/km²	Health care	Primary health care facilities
South Africa	59	5916	95	3.8	25	42	0.2	280	4352
Western cape	75	9381	97	4.5	9	27	0.1	319	531
Eastern cape	61	2856	92	2.9	22	58	0.3	166	780
Northern cape	59	6513	95	9.0	16	32	0.2	111	152
Free state	59	5185	94	2.7	30	45	0.2	309	298
Kwazulu-natal	53	4563	95	3.8	34	45	0.3	197	629
North west	54	3509	94	2.2	25	35	0.2	168	474
Gauteng	64	11862	92	2.8	30	44	0.2	826	438
Mpumalanga	58	6105	94	3.3	29	41	0.2	301	386
Limpopo	45	2019	93	2.8	15	57	0.2	195	664

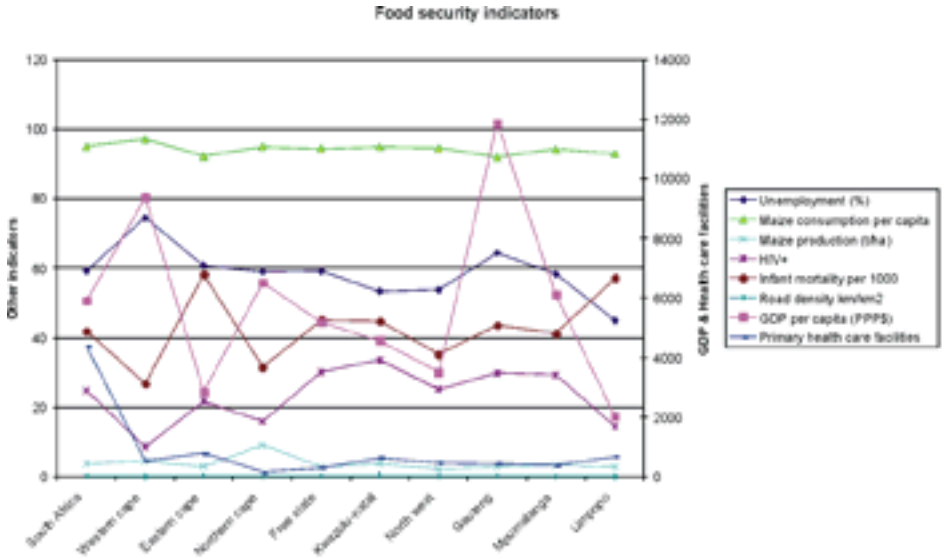


Figure 7 Profiles of food security indicators for South Africa

It is common in vulnerability mapping to transform the indicators to standard scores and then average them together into one aggregate index of food security. However, there are different methods of aggregating indicators. The simplest enhancement is to weight each indicator according to a specific concern, such as climate, economic shocks or health. Or, the number of indicators that exceed a threshold of concern might indicate the most serious conditions of vulnerability. More sophisticated models of the inter-relationships between indicators, such as the consequences of decrease in production for rural off-farm employment, would capture the concatenation of stresses. The choice of aggregation scheme can alter the overall score, as

shown for different weights and a threshold of effects (flags) in Table 7. Our strong preference is to use multi-attribute profiles and identify clusters of similar vulnerabilities rather than ranking based on a naive aggregation scheme.

Table 7 Aggregate food security in South Africa for different aggregation schemes

	Average	Climate	Economic	Health	Threshold
Eastern cape	45	39	40	52	29
Limpopo	47	37	42	56	43
Free state	47	41	46	50	43
North west	50	35	41	58	43
Mpumalanga	52	49	52	54	43
Gauteng	52	48	64	39	14
Kwazulu-natal	57	56	58	57	43
Western cape	69	70	65	76	71
Northern cape	81	110	85	86	86

Notes: Average is the average of the eight food security indicators. The dominant weights for climate are maize consumption and production, for economic shocks unemployment and GDP per capita, and health HIV and health care. The threshold is an indicator score of 50, with the number of indicators standardised.

Turning to scenarios of future food security, in this example we use two scenarios from the Global Scenarios Group PoleStar data base: Market Forces and Great Transitions. The process of relating the global scenarios to South African food security has an additional step compared to the India example. First, the PoleStar data are extracted for Africa. Then the African indicators are related to South Africa. The adjusted PoleStar values are related to the South African indicators of food security as shown in Table 8. It is recognised that South Africa differs from the rest of Africa and so these differences are quantified by using additions for where South Africa has higher rates and minuses where lower. Equals are used where the Africa variables are seen to be the same for South Africa. We comment on the methodology in the concluding section.

Table 8 Relationship between PoleStar indicators for Africa to South Africa

GSG Indicator	South Africa	GSG Indicator	South Africa
Pop growth rate	=	Hunger, %	+++
Urban fraction	=	Harvested area	++
Income per capita	+++	Production	++
Agriculture value added	++	N Fertiliser	++
International equity	+++	Yield	=
National equity	+++	Calorie intake	++
Gini	+++	Water withdrawals/resources	+++
Freight intensity	++	Water stress, %	+

Key:
= where the relationship is the same for the national and the continent
+ the country has higher values than the continent (++ and +++ represent values a lot higher)

The PoleStar variables that are related to food security are shown in Table 9. The population growth rate and change in the fraction of the population living in urban areas are assumed to be about the same in South Africa as for Africa as a whole. For most of the other indicators, South Africa is considerably better off, as a whole, than Africa: for example per capita income is higher and growth in income is likely to be stronger. The linking matrix between the PoleStar variables and local food security variables is not dissimilar to the case for India (Table 9). Income per capita and the prevalence of hunger have a strong relationship to several food security indicators. The distribution of income (national equity and the Gini coefficient) is also an important driver. The drivers of the road network are less clear.

Table 9 Links between PoleStar variables and South African food security indicators

	Unemployment	GDP per capita	Maize consumption/ capita	Maize production	Estimated HIV+	Infant mortality	Road density	Primary health care facilities
Pop. growth			-					-
Fraction living in urban centres	++				++			+
Income per capita	---	+++	+++			---	+	++
Agricultural value added	--			+				
National equity	--					--		+
Hunger prevalence			---			--		
Harvested area of wheat & coarse grains				+++				
Average daily per capita calorie			+++		-			
Water withdrawals/resources				++				
Yield for wheat & coarse grains				+++				
N Fertiliser applied, wheat & cg				++				
Water stress, %				--		+		
Freight Intensity							++	
Gini coefficient	++							

Key:
= where the relationship is the same for the national and the continent
+ the country has higher values than the continent (++ and +++ represent values a lot higher)
- the country has lower values than the continent

The results are shown in Figure 8. The Great Transition scenario indicates modest improvement in 2025 and quite dramatic increases in food security by 2050. The changes affect all of the indicators—all improve in the scenario. The differences between the Great Transition and Market Forces scenarios is as expected—substantial improvements are envisioned in the transition to sustainability vis-à-vis the predominant mode of development captured in the Market Forces scenario. These improvements are more significant in 2050, by which time the transition to sustainability is widespread (in the scenario).

Figure 8 Scenarios of future food security in South Africa

We have not related these South African scenarios to the provincial scale, but the same procedure could be undertaken as in the India example. The exercise is useful in order to highlight how different the provinces might be in terms of food security yet how little of this is addressed when working at a continental or national level. The relevance of global or national scenarios for understanding local dynamics is therefore often misleading and it is clear that methods for developing locally driven scenarios need to be further explored.

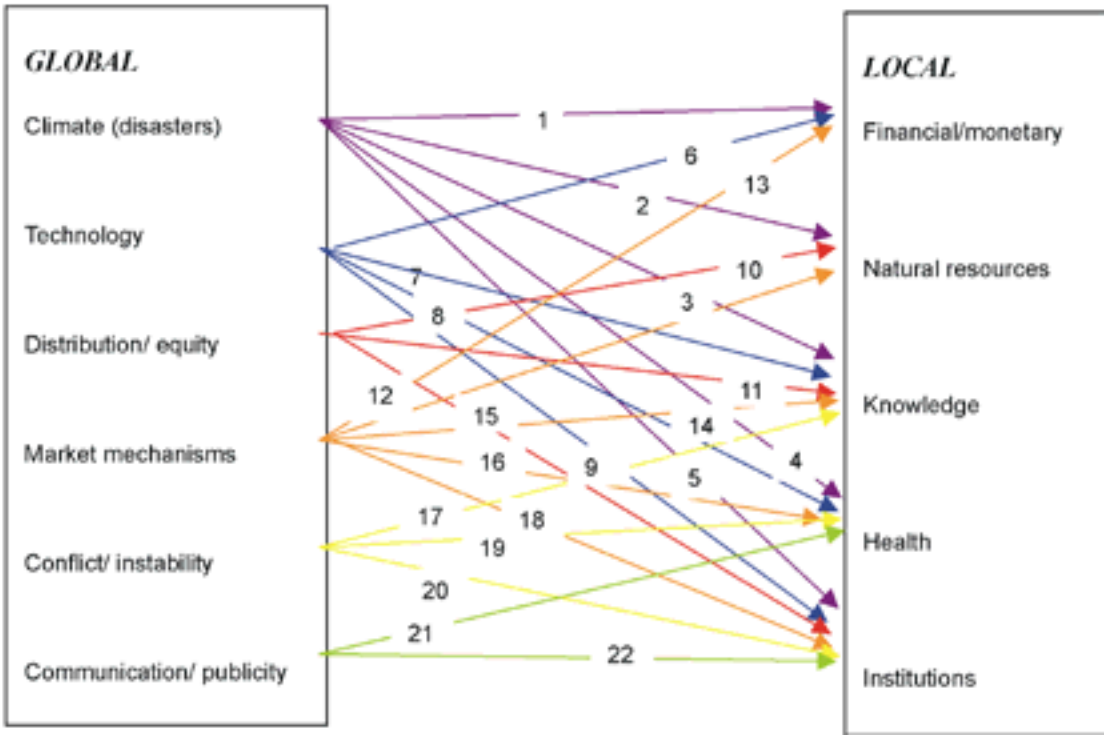
Livelihood Scenarios: From the Bottom Up

In this section we present a structured approach to creating local scenarios based on the exposure of livelihoods to a range of trends and shocks. We start by expanding on the nature of the local-global linkages. We then outline how training exercises using this approach indicate that it should be suitable for real applications by drawing upon the wealth of experience in participatory and rapid appraisal methods.

The challenge faced in current research at the local level is to understand not only how local groups have adapted to past changes but to start to explore how they might adapt better to a changing environment in future. It is clear that in order to do this, there should be some perception of how the environment might change and how the impacts that might be realised at the local level will affect these changes. In order to achieve this, the linkages between global and local environments need to be explored.

The global scenario methods need to be complemented with the 'grounded reality' of local conditions. This is particularly true for food security (Bergeron 1999). The rhetoric of globalisation, driving forces and poverty often fail to explain the variations in resources, entitlement and empowerment that are conditions of food insecurity at the local level. For example, in the South African case study above, the determinants of food security were considered at a provincial level. Although this might be more helpful to planners than national or continent level scenarios, these scenarios are still unlikely to capture the dynamics of what needs to be known about food insecurity at the household level in order to address it. Although policy and national level planning is important, it cannot be looked at in isolation away from the reality of what it means to secure food at the household level. It is therefore critical to have methods that allow for local scenarios to be developed and integrated into larger scale scenarios. At present, local level scenarios are underdeveloped.

Figure 9 starts to map some of the relationships between global stressors and local stresses as developed with a range of stakeholders in a participatory context. This can be used to establish which relationships appear to be more important (which can be represented by thicker lines). This method ensures that singular causal relations are not the focus but rather that the complex range of multiple stressors is acknowledged.



Source: developed in an AIACC workshop in South Africa, 2003

Figure 9 An example of mapping global drivers onto local livelihoods

Key: Description of linkages between global drivers and local indicators

Driver	#	Label	Driver	#	Label
Climate (disasters)	1	Insurance/ investment priorities	Conflict/ instability	18	Investment
	2	Compensation (more resources)		19	Displacement
	3	Awareness, research		20	Government priorities
	4	New diseases	Communication/ publicity	21	Cultural awareness
	5	Negotiations		22	Gender
Technology	6	Productivity			
	7	Migration			
	8	Efficiency, time, degradation			
	9	Monitoring, information			
Distribution/equity	10	Pollution; Refugees impact on environment	**Other drivers:**		
	11	Brain drain	Disease/health		Income/poverty
	12	Models of development	Energy		Legal – finance
Market mechanisms	13	Cash cropping; input subsidies			
	14	Forecast	Governance – macro policies		Cultural preferences
	15	Sanctions			
	16	Medicine			
	17	WTO demands			

Categories included in local indicators:

Financial/monetary	Access to financial support Remittances Multiple sources of household income	Health Institutions	Households Community National Regional International
Natural resources	Land, water, soil Amount of food available		
Knowledge	Local knowledge; access to education Technical support Technology		

Scenarios can help to suggest possible global environmental changes as outlined above, but once these drivers are established there are not many ways to examine the impact these global forces will have on local realities. Capturing the key relationships between global drivers and local dynamics is a useful starting point. An understanding of how these relationships might change in future will help to uncover how global scenarios might impact on local realities. Identifying the mechanisms that drive local outcomes can support this and help to uncover dynamic vulnerability. Vulnerability in outcomes is important but vulnerability in relationships, that capture the dynamic nature of the problem, might be more critical in understanding how future variability might impact on outcomes. This is also critical in contributing to facilitating improved adaptation.

Although some of the broad relationships between global stressors and local instability can be mapped, these relationships need to be further understood. Although the scenarios for food security in South Africa, presented in the above section, managed to break scenarios down so that they were relevant at the local level, it is clear that there were many elements that were excluded. A bottom-up process can help to capture elements that are critical to understanding vulnerability at the local level and when paired with the impact of global stressors, can help to understand how global-level change might impact on the local level in a plausible manner.

LIVELIHOOD SCENARIOS

In order to develop local level scenarios more fully, a participatory approach is required. The first step is a framing discussion that reviews the needs for socio-economic scenarios. This often reveals a wide range of purposes—it is likely that no one set of scenarios or approaches is able to cover all of the demands. Three examples of how scenarios are used are:

- Consistency in comparison between diverse sectors and places. This is a common view, often imposed on local projects by participation in regional or global assessments. Thus the SRES was compiled for a global view of GHG emissions futures. Or, global water scenarios are proposed for interpretation in regional and national dialogues to provide greater detail to the global level. Rarely are local scenarios scaled up.
- Range of potential futures. This is the most common response—scenarios are plausible futures that have some relevance to the local vulnerability and/or adaptation. The range might be sharpened to include a ‘worst case’ scenario of conditions under which adaptation would fail. Or, conversely a scenario which encourages effective adaptation. Interestingly, the most important driving forces of these two scenarios may not be the same.
- External factors. What are the constraints to local adaptation driven by national or global processes? This is a question of bounding the assessment and including external factors as formal scenarios to test the robustness of the system.

A more generic view of scenarios is to define pathways—the decisions, milestones and outcomes that might shape sustainable futures, or conversely those to be avoided. A very local interpretation of scenarios is a series of ‘what if’ evaluations of specific responses. For instance, what would be effective ways to achieve national self-sufficiency in food production, combining aspects of agricultural land use, water management for irrigation and fertiliser and other inputs. This could be further refined with an analysis of the sequence of decision making undertaken by households or stakeholders. For instance, exposure to malaria is a sequence

of linkages from climate-mosquito population, vector transmission, treatment and outcomes. It would be possible to construct a number of such pathways, for different livelihoods or vulnerable groups, and locate them in more general scenarios of the driving forces that govern choices and branch points in the decision tree.

An intermediate scale between the driving forces of global change and the local attributes of vulnerable people is the livelihood system. In creating local scenarios, starting with a livelihood presents a clear focus of social networks, economic activities and resource management. For example, nomadic pastoralists and smallholder maize farmers are examples of specific livelihoods exposed to different vulnerabilities. Common typologies of livelihoods or vulnerable groups are shown below in Table 10, for different sectors or areas of concern.

Table 10 Examples of typologies of livelihoods and vulnerable households

Geographic	Economic	Health status	Demographic
Rural	Nomadic pastoralists	Affected by AIDS	Women-headed households
Urban	Agro-pastoralists	Disabled	Elderly
Coastal	Emerging farmers	Malaria-prone regions	Pregnant women
Highland	Commercial farmers Fishing communities	Malnourised	Children under 5
Agro-ecological zone	Agricultural labourers (seasonal, landless, semi-urban) Agricultural industry and market traders Non-agricultural employment Unemployed Low wage, informal workers Formal sector workers		

For each of the livelihoods, it is possible to suggest how they would fare under different scenarios of future food security. In a training exercise, small groups of 5-8 can work with each livelihood under a common facilitation. This could be supported by further exercises that establish the type of pathways that led to the present situation.

A brainstorm by those involved at the grass roots or national level helps to identify influences on vulnerability at the local scale. A template for a group exercise could be presented on a flip chart in the centre of the group (Figure 10). A large white board and post-it notes (so the ideas can be re-arranged) would be ideal for a longer exercise. In the template, the rings reflect the main scales of the drivers, while the axes help organise the drivers into sectors (or related to the five capitals of sustainable livelihoods). However, these are only guides to help organise and interpret the ideas.

The global driving forces that affect local conditions of vulnerability need to be linked to the local conditions of livelihoods. For example, how does a global shift in the service economy (with many firms locating support staff in developing countries such as India) affect local labour markets for the poor? Or, how does persistence of trade barriers (or their potential removal) in Europe and the US affect the poorest subsistence farmers? Such probing questions often reveal the importance of intermediary actors and institutions in translating global risks to the local level or controlling access to global opportunities.

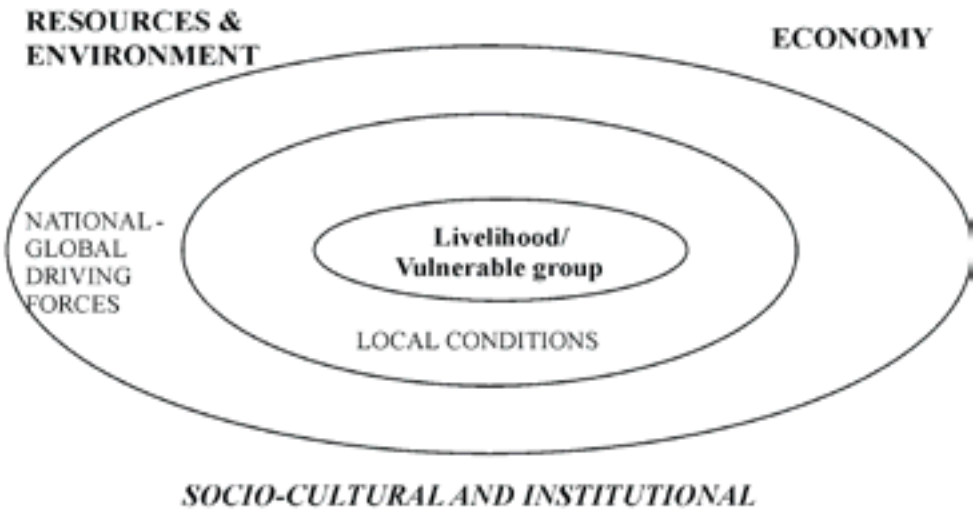


Figure 10 A template for mapping the exposure of livelihoods and vulnerable groups to trends and threats in resources, the economy and socio-institutional change

The links can be further characterised. What is the nature of the link? It might be a physical connection of materials and mass balance (water, produce), finance and economic exchange, and/or information and advice.

The nature of the links are direct material flows (blue), economic transactions and finance (green) or information (red). The thickness of the arrows indicates the relative importance, in this example of the drivers of local vulnerability. The three most important local (or proximate) factors are shown in bold: drought, farm prices for produce in the local market or for regional exports, and access to health and education.

These processes form a baseline of linkages and a template for discussing questions that can be used to build up future scenarios:

- Are some driving forces correlated? In constructing formal scenarios it is important to avoid improbable relationships. For instance in a high growth, high equity scenario poverty should be reduced at the local level as well (unless there are other confounding circumstances).
- What would be the dominant factors in a 'worst case' scenario? In a development scenario? Or other scenarios that match the purpose of the exercise. These driving forces could be highlighted during the exercise, or separate charts could be produced later.
- How would the local vulnerabilities and bottom-up scenarios link to existing (or new?) global scenarios? Many assessments seek to relate their work to existing scenarios, such as SRES (for climate change, although this has some obvious problems for vulnerability), sectoral reviews (such as the Millennium Assessment or Global Water Scenarios), or even national development projects. The links may not be strictly determinate—that is a global scenario may be consistent with several local conditions. On the other hand, common drivers may appear at the local level that link readily to global scenarios. Translating the qualitative narrative developed in this exercise into numerical models and indicators is a further challenge.
- Comparing other livelihoods. It is interesting to compare several livelihoods and look for common elements that might then be combined in a cross-sectoral scenario of vulnerability.

This process of building a scenario is based on expert knowledge and stakeholder techniques. To be considered a robust and authentic process it may be desirable to repeat the exercise with different groups and see if they converge along similar lines. Or at least review the results widely.

Figure 11 shows an example of a mapping of the drivers of local vulnerability for smallholder farmers in a sub-humid region. The main factors of local vulnerability are drought, variable farm prices and lack of health and education facilities. Each of these can be linked to driving forces at the national and international level. The relationships include direct material flows (climate change alters regional weather patterns and rainfall), finance and economic transactions (credit from regional and national import-export banks) or information (transfer of knowledge and technology from international organisations to the National Agricultural Research System (NARS).

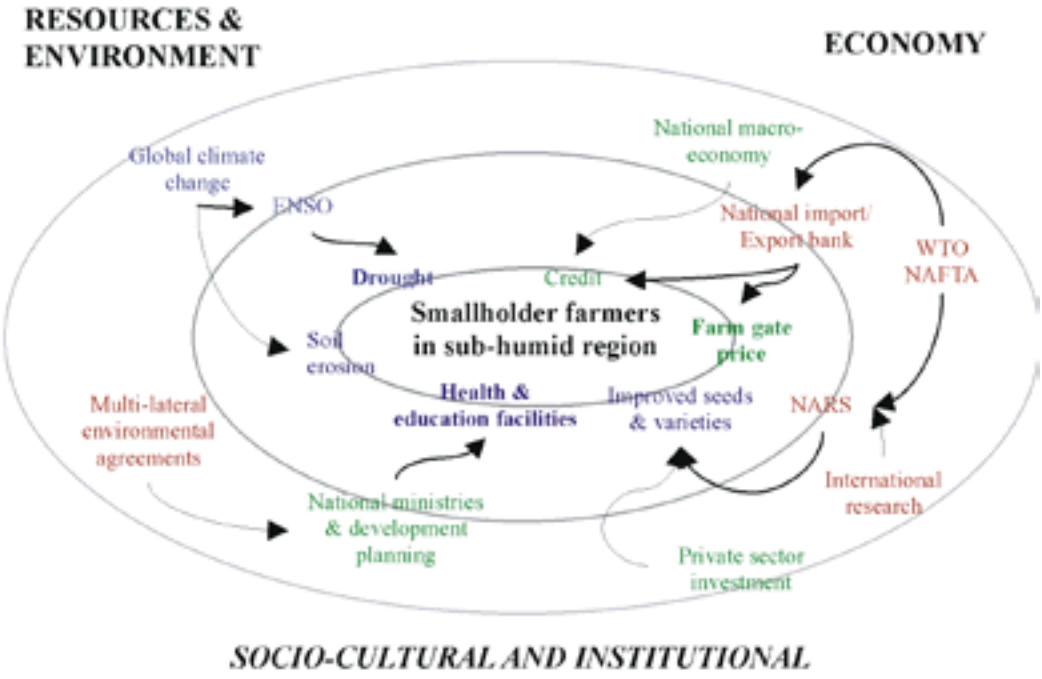


Figure 11 An example of mapping the exposure of livelihoods and vulnerable groups to trends and threats in resources, the economy and socio-institutional change

Going a step further, it would be possible to construct narratives around combinations of specific drivers. For example, two extremes might be:

- Market exploitation. Farmers in this region experience high levels of climatic risk and private investors are unwilling to develop agricultural markets when other regions are more accessible and productive. Trade agreements and weak economic performance leave the government with little room for subsidising agriculture in the region, which remains oriented toward staple foods for household consumption. A prolonged drought related to heightened ENSO phases reveals the vulnerability of agricultural livelihoods.
- Climate adaptation. International agreements on climate change begin to stabilise the climate system, albeit drought frequency has increased. Regional and global agreements on disasters, climate adaptation and millennium development goals have mobilised additional resources to provide effective early warning, preparedness and efforts to drought-proof the local economy. Previously vulnerable livelihoods are better integrated

into the regional and national economy and able to save during good years to weather the droughts.

Of course, these are only two ideas. But following the mapping in the example, it would be possible to develop locally relevant families of scenarios of future food security and insecurity.

Conclusion: Methodology and Practice in Linking Global and Local Scenarios

What have we learned in our review of food system scenarios and their potential application in global change assessments? First, the basis for developing useful, realistic scenarios is the conceptual framework. The conceptual framework guides the selection of indicators. We have seen that the link between sustainability indicators in PoleStar and the local indicators of food security are tenuous. Similarly, sectoral scenarios, such as for water or health, may not cover the multiple stresses of vulnerability. Analytical models that lead to scenarios reflect some sort of conceptual framework. Often implicit, the conceptual framework can have significant effect on results. A case in point is the IPCC SRES process (Nakicenovic and Swart, 2000). The SRES were developed to capture a wide range of plausible pathways of future greenhouse gas emissions without the implementation of mitigation measures (the so-called reference case). As such, they are for a very specific purpose and would not be suitable for studying the residual impacts of climate change (with GHG mitigation adopted) or for use in sustainability studies (where climate policy should be integrated). A critical concern is that developing countries in the SRES are all wealthier than they are at present, and most are wealthier in the 2050s-2080s than the OECD average is at present. Clearly, such optimistic views of nearly universal development would limit the exposure to climate impacts, possibly to rather small marginal effects on growing economies. The paradox is that such a construction of vulnerability would lead to low estimates of the social cost of carbon that do not justify present mitigation efforts (Pearce, 2003).

Secondly, aggregation of indicators remains a contentious area in vulnerability assessment, and one that scenario evaluation cannot ignore. We prefer multi-attribute profiles, such as the South African food security dimensions of food availability (physical); food access (economic); reliability (nutrition and quality) and distribution (spatial and temporal). This method enables the components of food insecurity to be highlighted in order to ascertain how vulnerability to food insecurity differs between places. Ranking of vulnerability between livelihoods (that is to say pastoralists are more vulnerable than fishermen) is methodologically suspect and possibly dangerous, although an understanding of the dominant types of vulnerability within each livelihood can be useful for targeting intervention. The strength is that the approach can help to identify elements of key concern for each group and these points can then be investigated further.

Third, a broader concern is the participation of stakeholders in developing scenarios. Scenarios are not predictions, rather they are visions and semi-quantitative explorations of potential futures. The PoleStar database is of less use than a thoughtful reflection on the character of the alternative worlds. Similarly, a radar plot of vulnerability on selected indicators is of little interest if it does not stimulate awareness of the reality of those groups. This narrative—the qualitative storylines that explore the present and possible pathways—is the domain of political ecology and vulnerability assessment (Franklin 2004).

The process of creating narratives can be creative and stimulating for stakeholders (as well as experts). Local narratives are likely to be more creative and insightful, and certainly more directly related to the stakeholders' domains of action, than global storylines in marker scenarios already identified by experts. This presents a fundamental constraint to creating scenarios—at the global scale it is difficult to engage the local stakeholders who matter (and even the global actors may not wish to be involved in the process). At the local level, stimulating participatory processes can be launched, but their integration at the global may be weak.

At present, the global-local linkages tend to be through the adoption of the same framework (the choices of the main drivers, such as environmental awareness and social responsibility) or even through the use of the same broad storylines (a global stewardship scenario is almost universal in such exercises). Yet, we have seen that the drivers of local vulnerability are quite distinct from the global forces.

Fourth, a promising approach would be to use livelihood systems as the intermediary between the global driving forces and the local conditions of vulnerability. This would allow the analyst to create scenarios for each livelihood group, relevant at the local level, and then explore how those livelihoods might change in the context of different global scenarios. These could be accompanied by narratives that expand on certain relationships.

For example, we might describe three livelihoods in rural India and South Africa (to draw upon our previous examples): coastal artisanal fishing in India, smallholder irrigated rice farmers in India, and semi-subsistence rainfed maize smallholders in South Africa. If we compare two of the Global Scenario Group scenarios, we can readily delineate the kinds of changes that would be consistent with their global perspectives (Table 11). Under continued market forces, vulnerability for these livelihoods may well increase as larger commercial enterprises control access to markets, credit and technology. The vision of sustainability is also more egalitarian with local control of resources and cooperatives ensuring poor farmers benefit from development initiatives.

Table 11 Examples of livelihoods in global scenarios

Livelihood	Market Forces	Great Transitions
Artisanal fishing	Larger commercial fleets dominate fishing grounds; traditional fishing is confined to in shore catches. Trading markets depend on reliable volume provided by larger operations, artisanal fishers are restricted to local markets with variable demand.	Sustainable resource management assigns fishing rights to local authorities who prevent large commercial operations from over-fishing local area. Markets are cooperatives with shared facilities and access.
Irrigated rice	Privatisation of water schemes increases the cost of irrigation. This is reflected in higher food prices, but leaves poor farmers worse off as they cannot afford the finance to maintain their production systems.	Local cooperatives and catchment water planning committees manage resources sustainably, ensuring poor farmers have access to water.
Rainfed maize	Maize production continues to be developed by the private sector with increased use of commercial inputs including genetically modified organisms. Poor farmers have less access to the international markets than the larger commercial farmers who have access to credit and export guaranties. Thus vulnerability amongst the most poor—also affected by ill health, poor sanitation and drought—increases even in a growing agricultural economy.	Markets continue to develop but local cooperatives ensure that a large proportion of purchases are from vulnerable farmers in an extension of fair trade schemes that includes micro finance for development. Organic demand increases providing a niche for many of the low input farmers.

We can depict the meso-scale of livelihood systems as linking between global drivers and local conditions of vulnerability (Figure 12). Clearly global drivers affect local conditions, which in turn shape the current and future vulnerability of livelihoods. The vulnerable, however, are not passive and respond to events and threats to modify their prospects. There are possible feedbacks between livelihoods and global drivers or local conditions and global drivers—however these are seldom strong feedbacks and rarely included explicitly in socio-economic scenarios of this nature. Two ways of incorporating livelihoods are indicated. It is possible to extend global scenarios with a livelihood-actor layer. Alternatively, it is possible to situate local conditions within existing global scenarios. The more ambitious effort is to treat both scales simultaneously as essential constructs for understanding the prospect of vulnerable livelihoods.

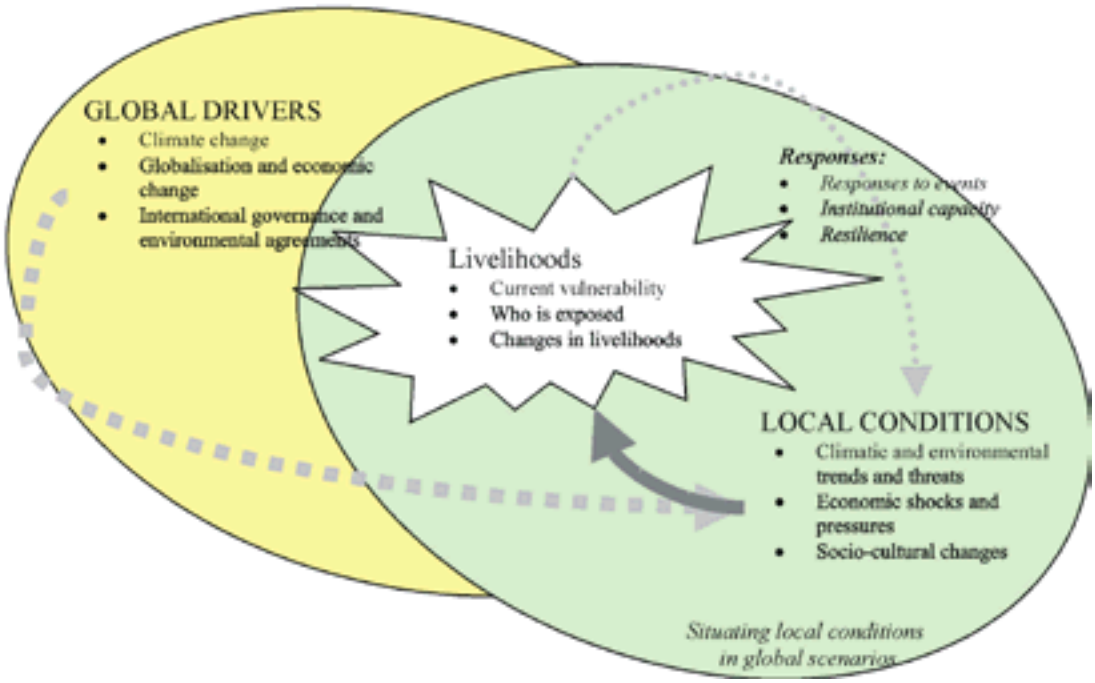


Figure 12 Livelihoods as links between scenarios of global drivers and the local conditions of vulnerability

This example leads to a more general observation about the downscaling of global scenarios. The livelihood groups shown in Table 11 become more vulnerable in the Market Forces scenario, in contrast to the implied improvement in the food security indicators noted above. In any global scenario, there are likely to be residual pockets of vulnerability and food insecurity. The lack of a strong signal from global to local, and indeed the necessity of poverty to continue in some scenarios of uneven development, are often ignored in global scenario exercises.

Present scenarios tend to be static constructions of the future. That is, they present a snapshot of a plausible vision for, say, the 2020s. Sometimes the scenarios backcast from the snapshot to the present to identify flash points and decision nodes in pathways that could plausibly achieve the future state of affairs. Frequently, such exercises are confined to estimating the range of growth rates in population growth or economic growth that might prevail.

Of course, reality is far more complex—a series of interactions of individuals and institutions, of environments and economies, of expectations of the future and goals. This is also the dynamic context of vulnerability. To reflect such complex realities at multiple levels is well beyond the ability of expert-consensus scenario processes. However, progress in agent-based simulation and models of complexity suggests that behavioural scenarios might be constructed. In such a case, the scenarios would be guided by norms of decision making and the variance among individuals in social networks, rather than the intended outcomes. For example, a rule might be to maximise net revenue to a corporation rather than achieve an increase in GDP per capita of 2% per year (although this might be the goal for an economic planner). Scenario games with real stakeholders and the public guided by agent-based models might result in a plethora of different decisions over time and pathways from the present. It is not inconceivable to assemble thousands of such scenarios. This data set could then be explored to identify common visions and critical branch points. It would be a project on the same order of magnitude as ensemble predictions from global climate models.

Related to the static nature of scenarios is their ability (or not) to represent realistic processes of adaptation. Some scenarios assume a link between, for instance, economic wealth and technological innovation, the latter driving rates of energy efficiency improvement, maximum crop yields, or the extent of malaria prevalence. These are hardly the processes of exposure, risk assessment and multi-stakeholder adaptation that we recognise in practice.

An extension of the notion of dynamic, behavioural scenarios would begin to address adaptive processes. If our present understanding is true—that the underlying vulnerability is more important than climate change over the next two decades or so—then large scale scenarios of vulnerability and adaptation should be a realistic objective for understanding climate adaptation.

Acknowledgements

This research has been supported by the SEI/Sida Poverty and Vulnerability Programme, the U.N. Environment Programme project on climate change adaptation in Orissa, India, with the National Centre for Agricultural Economics and Policy Research and the CLOUD project of the School of Geography and Environment in Oxford University, funded by the Tyndall Centre.

The research has been developed in interactions with several climate change and vulnerability projects. The first exercise was with researchers at the AIACC workshop in South Africa in 2003, followed by a similar exercise at the SEI in Stockholm. The concepts were further elaborated through discussions with the UNEP/NCAP project on Orissa, India, several meetings related to the Adaptation Policy Framework, and support to the National Adaptation Programmes of Action.

The authors remain solely responsible for any errors in the present working paper.

References

Adam, H. and K. Moodley (1993). "Forecasting scenarios for South Africa." *Futures* 25(4): 404-413.

Berger, P. L. and B. Godsell (1989). *A Future South Africa: Visions, Strategies, and Realities.* Boulder Co, Westview Press.

Bergeron, G. (1999). *Rapid Appraisal Methods for the Assessment, Design, and Evaluation of Food Security Programs.* Washington, IFPRI.

Carney, D., Ed. (1998). *Sustainable rural livelihoods: What contributions can we make.* DFID's Natural Resources Advisers' Conference (July 1998). London, Department for International Development (DFID).

Cash, D. W. and S. C. Moser (2000). "Linking local and global scales: Designing dynamic assessment and management processes." *Global Environmental Change - Human and Policy Dimensions* 10: 109-120.

Downing, T. E., R. Butterfield, S. Cohen, S. Huq, R. Moss, A. Rahman, Y. Sokona, and L. Stephen (2001). Climate Change Vulnerability: Linking Impacts and Adaptation. The Governing Council of the United Nations Environment Programme (UNEP). Oxford, University of Oxford: 39.

Franklin, S. (2004). "Towards a narrative theory of climate change vulnerability." *Annals of the Association of American Geographers* (Submitted).

Hoddinott, J. (1999). *Targeting: Principles and Practice*. Washington, IFPRI.

Lutz, W., W. C. Sanderson and S. Scherbov, Eds. (2004). *The End of World Population Growth in the 21st Century, New Challenges for Human Capital Formation and Sustainable Development*. London, Earthscan.

M.S. Swaminathan Research Foundation (2001). *Atlas of Rural Food Insecurity in India.* Chennai, MSSRF.

M.S. Swaminathan Research Foundation (2002). *Food Insecurity Atlas of Urban India.* Chennai, MSSRF and World Food Programme.

M.S. Swaminathan Research Foundation (2004). *Atlas of the Sustainability of Food Security in India.* Chennai, MSSRF.

Mano, R., B. Isaacson, and Dardel, P.(2003). *Identifying Policy Determinants of Food Security Response and Recovery in the SADC region: The Case of the 2002 Food Emergency,* FANRPAN.

Nakicenovic, N. and R. Swart, Eds. (2000). *Special Report on Emissions Scenarios.* Cambridge, Cambridge University Press.

National Department of Agriculture (NDA) (2002a). *Abstract of South African Agricultural Statistics.* Pretoria, NDA.

National Department of Agriculture (NDA) (2002b). *The Integrated Food Security Strategy For South Africa.* Pretoria, NDA.

Pearce, D. (2003). "The social cost of carbon and its policy implications." *Oxford Review of Economic Policy* 19(3).

Rosegrant, M. W., X. Cai, et al. (2002). *Water and Food to 2025. Policy Responses to the Threat of Scarcity*. Washington, DC, International Food Policy Research Institute (IFPRI) and the International Water Management Institute (IWMI).

Seaman, J. (2000) Making exchange entitlements operational: the Food Economy Approach to famine prediction and the Risk Map computer program. *Disasters,* 24(2):133-152. Oxford: Blackwell Publishers.

Seaman, J., Clarke, P. Boudreau, T. and Holt, J. (2000). *The Household Economy Approach: a resource manual for practitioners,* Development Manual 6, London: Save the Children (UK).

Stephen, L. and T. E. Downing (2001). "Getting the Scale Right: A Comparison of Analytical Methods for Vulnerability Assessment and Household-level Targeting." *Disasters*(25(2)): 113-135.

Sunter, C. (1987). *The World and South Africa in the 1990s*. Cape Town, Human & Rousseau Ltd/ Tafelberg Publishers.

UNAIDS. (2004). 2004 report on global trends in the HIV/AIDS epidemic. Joint United Nations Programme on HIV/AIDS.

Vogel, C. and J. Smith (2002). "The politics of scarcity: conceptualizing the current food security crisis in southern Africa." *South African Journal of Science* 98(7/8): 315-317.

Ziervogel, G. (2004). "Targeting seasonal climate forecasts for integration into household level decisions: the case of smallholder farmers in Lesotho." *The Geographical Journal* 170(1): 6-21.

The Stockholm Environment Institute (SEI)

SEI is an independent, international research institute specializing in sustainable development and environment issues. It works at local, national, regional and global policy levels. The SEI research programmes aim to clarify the requirements, strategies and policies for a transition to sustainability. These goals are linked to the principles advocated in Agenda 21 and the Conventions such as Climate Change, Ozone Layer Protection and Biological Diversity. SEI along with its predecessor, the Beijer Institute, has been engaged in major environment and development issues for a quarter of a century.

Mission

SEI's mission is to support decision-making and induce change towards sustainable development around the world by providing integrative knowledge that bridges science and policy in the field of environment and development.

The SEI mission developed from the insights gained at the 1972 UN Conference on the Human Environment in Stockholm (after which the Institute derives its name), the work of the (Brundtland) World Commission for Environment and Development and the 1992 UN Conference on Environment and Development. The Institute was established in 1989 following an initiative by the Swedish Government to develop an international environment/development research organisation.

Risk and Vulnerability Programme

This programme conducts research on environmental and technological hazards and global environmental change. Expanding on ongoing and previous work on risk analysis, risk perception, and risk management, research now also focuses on the differential vulnerability of people, places, and ecosystems. The hallmark of this programme is integrated analyses that seek to bridge the best of the social and ecological sciences. A major priority is the development of policies and initiatives that hold promise for enhancing human security, adaptive capacities, social equity, and resilient societies.

Stockholm Environment Institute

SEI-HQ
Director: J. Rockström
Box 2142
S-103 14 Stockholm
Sweden
Tel+46 8 412 1400
Fax+46 8 723 0348
E-mail postmaster@sei.se
www.sei.se

SEI-Boston
Director: P. Raskin
11 Arlington Street
Boston, MA 02116-3411
USA
Tel+1 617 266 8090
Fax+1 617 266 8303
E-mail seib@tellus.org
www.seib.org

SEI-Tallinn
Director: V. Lahtvee
Lai 34, Box 160
EE-10502, Tallinn
Estonia
Tel+372 6 276 100
Fax+372 6 276 101
E-mail seit@seit.ee
www.seit.ee

SEI-York
Director: J.C.I. Kuylenstierna
University of York
Heslington, York YO10 5DD
UK
Tel+44 1904 43 2897
Fax+44 1904 43 2898
E-mail seiy@york.ac.uk
www.seiy.org

SEI-Asia
Director: T. Banuri
9th Floor, Park Place Building
231, Sarasin Road, Lumpinee,
Pathumwan, Bangkok,
Thailand
Tel+66 (0) 2 254 2260-5
Fax+66 (0) 2 253 2234
www.sei.se/asia

ISBN 91 975238 1 X