

Full Length Research Paper

Global environmental change and food systems in Southern Africa: The dynamic challenges facing regional policy

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Accepted 17 March, 2011

There is a growing concern that Global environmental change (GEC) will exacerbate the stress on Southern African food systems leading to increasing food insecurity, which is signified by rising levels of chronic and severe malnutrition and rates of stunting in children. The situation is further exacerbated by insufficient understanding on how the region's food systems currently operate, in which ways they are vulnerable to GEC and what types of adaptation options are most likely to be viable at present and in the future. This paper identifies key research challenges to food system vulnerability and the impacts of GEC; policy and technical adaptation options; and possible consequences of different adaptation pathways, set in the context of regional socioeconomic and environmental conditions.

Key words: Southern Africa, food security, global environmental change (GEC), policy formulation, food systems.

INTRODUCTION

There is widespread recognition that Global environmental change (GEC) is unequivocal (IPPC, 2007). Human activities, including those related to the production, supply and consumption of food, are partly responsible for changing the world's climate and giving rise to other, globally- and locally-important environmental changes (Vitousek et al., 1997; Steffen et al., 2004).

There is growing concern that GEC will further complicate achieving food security, particularly for more vulnerable sections of society (Fischer et al., 2001; Rosegrant and Cline, 2003; Parry et al., 2004). GEC

impacts the food systems that underpin food security in Southern Africa. Crop, livestock and fisheries productivity is affected by environmental changes resulting from GEC. Extreme weather events affect physical infrastructure, which in turn disrupts food storage and distribution. Lastly, food consumption is affected by impacts to food prices and hence access (Liverman and Kapadia, 2010).

For Southern Africa, numerous studies based on observed and projected changes highlight the risk of deteriorating conditions for an already vulnerable subsistence-farming sector, such as the occurrence of more extreme temperature events, later onset of the rainy season (Tadross et al., 2005), and general decline in rainfall (Ngondongondo, 2006). GEC is expected to affect Southern Africa across sectors including health (Haines

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et al., 2006), agriculture and food security (Gregory et al., 2005), and water management (Arnell et al., 2003). There is also concern that agricultural growth required to meet society's rising demand for food will further degrade the environment (Tilman et al., 2001; Bruinsma, 2003), and that this will, in turn, further undermine food systems and destabilise long term food security.

GEC and food security was identified as one of the top priorities for Africa by the 2005 AFRICANESS workshop¹. Given the complexity of interacting socioeconomic and GEC-related factors to be discussed subsequently, the food security situation is particularly critical in Southern Africa; GEC is already adding further stress to what is already a complicated and tenuous food security situation for many (Misselhorn, 2005).

The objectives of this paper are two-fold. First, it highlights how GEC is adding stress to Southern Africa's currently fragmented and under-developed regional food systems, thereby further undermining food security. Second, the paper argues for the adoption and implementation of a stronger and wholesome Southern African Development Community (SADC)-wide regional food policy strategy as key to the vulnerability of the region's food systems to GEC and thereby minimising the prospects for chronic regional food insecurity.

The paper is a review of analytical and theoretical literature, empirical studies and policy papers, which, together with a series of workshops and discussions conducted with key stakeholders, have been synthesized to develop recommendations and conclusions. A set of consultative meetings were convened in Southern Africa by the Global Environmental Change and Food Systems (GECAFS) research project, which highlighted concerns that GEC will further complicate achieving regional food security.

BACKGROUND

Global environmental change

GEC is now occurring at an unprecedented scale of human intervention in the earth system. It includes changes in the physical and biogeochemical environment, either caused naturally or influenced by human activities such as deforestation, fossil fuel consumption, urbanization, land reclamation, agricultural intensification, freshwater extraction, fisheries over-exploitation and waste production. It includes: Changes in land cover and soils; biogeochemical cycles and atmospheric composition; biodiversity, climate and extreme weather events; sea level and ocean chemistry and currents, and freshwater quality and availability (Liverman and Kapadia, 2010).

Many climate change assessments conclude that Southern Africa will be significantly affected by climate change: The region is expected to become warmer and drier with a temperature increase of 2 to 5°C predicted over coming decades (Hulme et al., 2001; IPCC, 2001, Chapter 10-Africa; IPPC, 2007; Lobell et al., 2008). An increase in extreme events (both droughts and floods) is also anticipated (IPCC, 2001; Tyson et al., 2002), in the reduced and increasingly variable rainfall with a shift in the wet season for most of the land mass of the region occupied by Namibia, Botswana and parts of Zimbabwe and South Africa (Scholes and Biggs, 2004).

In addition to climate change-related impacts, disturbances such as fire and soil and range degradation resulting from land use management are already widespread, with concomitant loss of biodiversity (IPCC, Chapter 10 Africa, 2001; Yirdaw, 1996). Despite the fact that national research institutions, in collaboration with international programmes, have developed appropriate natural resources management technologies implemented through community based organizations; the rate of land degradation in many countries is faster than the speed of technology adoption.

Issues of water availability are also a growing concern (Arnell et al., 2003), with the inter-annual variability of hydrological regimes, already much greater than the inter-annual variability in rainfall (Tyson et al., 2002). The ratio of rainfall to evaporation in Southern Africa is the lowest in the world (O'Keefe et al., 1992). Although the region has large underground water resources, much of this is not suitable for consumption. Water shortages are already a constraint in the region's more developed countries and the anticipated warmer and drier conditions will both further reduce the water supply and increase demand (de Wit and Stankiewicz, 2006). Sub-optimal catchment management is leading to increasing siltation of water reservoirs and deltas with other downstream impacts on fisheries (e.g. in Lake Malawi and Kariba Dam) and on sea-port infrastructure (e.g. Beira in Mozambique) (Moyo et al., 1993).

In light of these existing and anticipated environmental changes, are the region's food systems best adapted to make optimum use of the region's diverse range of biophysical resources and environmental endowments?

Southern African food systems

Food security is underpinned by food systems. Food security is the state achieved when food systems operate such that 'all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life' (FAO, 1996). Food security is diminished when food systems are stressed. This can be caused by a range of factors in addition to GEC (e.g. conflict, changes in global food market situations and trade protocols, AIDS, tuberculosis and malaria epidemics).

¹ AFRICANESS: African Earth System Science Conference, Nairobi, September 2005, organised by ESSP and ICSU and supported by NSF, NEPAD and NRF.

These factors pose a particularly severe threat to food security when they act in combination, as is now the case in Southern Africa.

Food systems encompass two main aspects (Ericksen, 2008). *Activities*, which relate to producing, processing, distributing, preparing and consuming food; and the *outcomes* of these activities, which contribute to the three components of food security: Availability, access; utilisation of food. Interactions between and within the bio-geophysical and the human environments influence both activities and outcomes of the food system. Both aspects are underdeveloped and have limited resilience in Southern Africa and warrant policy attention. An examination of the major features of the region's food systems helps to identify both where GEC will likely have an impact and where policy and/or technical options can help overcome constraints.

Food production

Producing food is clearly a fundamental agricultural and industrial activity contributing to food security outcomes. The majority of producers in Southern Africa are poor, indigenous populations practicing semi-subsistence agriculture driven in their farm operations by a desire to secure a satisfactory and secure livelihood. Their farming systems are dominated by food crops and traditional, long-established production technologies and practices that are adapted to maximize average yields and survival under local climatic conditions.

The numbers of commercial producers in most Southern African countries is small, but they make a substantial contribution to total production. In contrast, there are many subsistence producers, but their scale of operations is relatively small. The advantages from which commercial producers historically benefited (such as subsidies, cheap water and labour) have now been abolished. In Zimbabwe, land re-distribution policies have resulted in a significant reduction of commercial farmers.

In terms of regional food crop production, maize clearly dominates (81% of production) followed by wheat (8.3%), sorghum and millet (7.4%), and rice (3.4%). No major shift in crop choice is apparent. Production obviously decreases during droughts, but overall production shows a cautiously upward trend: The average annual production rose from 21.8 million tonnes in the period 1990 to 1996 (excluding the 1992/93 drought) to 22.5 million tonnes in the period 1997 to 2003. At the regional level, the 2009/10 marketing year maize supply/demand balance projects a surplus of 2.68 million metric tonnes (FEWSNET, 2010). This means that the region has currently enough maize to cater for the needs of deficit countries, and still leave a surplus before trade. There are however marked national differences. Most of this surplus comes from South Africa, which contributes approximately 50% of the region's total production. In most years, the region should be self sufficient in grain

production as production exceeds the 'normal' consumption estimated of about 26 million tonnes (2004/2005 SADC estimate).

Food distribution: Road and rail

An effective regional food distribution system is critical for alleviating food insecurity whenever local production cannot meet demand. The recent famine situation in inland countries of Zimbabwe, Swaziland, Lesotho, Zambia and Malawi exposed the capacity limitations of the region's transport, warehousing and port facilities. The two principal transport networks in Southern Africa are road and rail.

The overall trunk transport network in the region can be characterised into six transport corridor groups comprising a set of coastal seaports linking into the hinterland through rail and road networks. The distances involved from seaports to the hinterland cause major complications to food distribution in the region (Table 1). Furthermore, in all cases, there are a number of transshipment points, e.g. transshipment of cargo between the Tanzania-Zambia Railway Authority (TAZARA) and Tanzania Rail Corporation due to differences in rail gauges. These cause additional stressors to the already poor food transport networks.

The scattered pattern of rural settlements in much of the region leads to a low density of road networks, ranging from 0.01 to 0.47 km of road per km². This is far below the 0.30 to 0.45 km per km² in many Asian countries (Stilwell, 2000) and Zimbabwe and South Africa are the only countries with road densities similar to the Asian averages.

Food storage and grain reserves

Generally, most grain handling and storage facilities are located on the main lines of rail and road networks with little coverage in the remote and rural areas of most Southern African countries. A comparison of the storage capacity with production estimates and consumption figures shows that most SADC countries have inadequate storage capacities yet the situation has not changed significantly since the 1992 to 1993 crises due to little additional capital expenditure. The SADC Council of Ministers have agreed that a regional food grain reserve should be re-visited and should include consideration of both a physical reserve and a financial facility.

Food imports and trade

To supplement *in situ* food production, food imports at both regional and national levels contribute significantly to food availability. The main imported grain is maize closely followed by wheat and rice. Imports of sorghum

Table 1. Key characteristics of subsistence and commercial producers.

	Subsistence producers	Commercial producers
Numbers	Large	Small
Size of operations	Small	Medium to large
Strategy	A secure, diverse and improved livelihood through agricultural and non-agricultural activities. Risk control and minimisation The input allocation to food production depends on the opportunities.	Maximising income from producing food Risk takers
Inputs	Low external inputs Operate usually on communal land systems, and holdings are not necessarily delineated or fenced off.	High level of external inputs Usually on private/fenced land. Commercial producers may also be found in communal lands, usually in fenced-off parts.
Type of products	Multiple, used for own consumption	Few, specialised products for sale
Equipment	Minimal	Mechanisation and intensification (e.g. irrigation)
Financial capital	Minimal	High and access to credit
Practices	Low-input low-output system Simple practices aimed at diverse and secure yields Competition for household inputs with non-agricultural sector	High-input, high-output system Modern practices aimed at profit maximisation
Human resources	Mostly indigenous agricultural/fisheries skills	Mostly modern agricultural/fisheries and management skills
Status	Many are food insecure	Food secure, but profitability variable and dependent on government support
History	Often disadvantaged (e.g. South Africa, Namibia and Zimbabwe)	Historically advantaged with access to best land, sufficient water resources and subsidies
Policies and politics	Political and donor priority Access and use of support is often limited Need to improve agricultural capabilities and production	Reduced political power Subject of substantial reforms (e.g. land, access to water, subsidy policies)

Source: SADC-FSTAU (1993).

and millet are very small, and confined to a few countries (Botswana, Zimbabwe and South Africa).

Koester (1993) compared food production patterns in Malawi, Tanzania, Zambia and Zimbabwe with the suitability of growing such crops and revealed a large difference in the grain growing potential among the four countries. This again raises the question of intra-country and inter-country trade in grains in Southern Africa. Trade has however been hampered by national policies that promote self-sufficiency policies, lack of or poor transport infrastructure and skewed pricing policies. Also adding to these problems are trade barriers experienced between countries in the region.

Food aid

While regional and national production can potentially meet the bulk of regional food security requirement, recent years have seen an increasing reliance on food aid especially during periods of drought. For instance, the drought year of 1992/93 was devastating for much of the

region, resulting in 10.3 million tonnes of food being imported into the region of which 31% was food aid. Since 1999, the amount of food aid imported ranged from 10 to 23% of the total cereal imports (FEWSNET, 2005). If current food policies and strategies fail to adapt to Southern Africa's changing environmental conditions as GEC accelerates, the need for food aid will grow and become more frequent where countries or consumers cannot afford to purchase food. This trend is already discernable at the local and national level. Two critical determinants of the success of food aid are the quality of external response to food aid requests and the availability of adequate distribution and communication networks within the region (IRC, 2005).

Food access and the increasing role of supermarkets

Food security is governed not only by food availability but also by access to food. Often this is closely linked to food affordability, which is in turn linked to both livelihoods and the basic costs of food. Nine-tenths of maize produced in

Sub-Saharan Africa goes directly for human consumption (Bänziger and Diallo, 2001). The price of white maize (the preferred staple food) on the South African Futures Exchange (SAFEX) stabilized in March, 2005, about 45% below a high point in November 2004, and experienced a dramatic increase in 2007/08 due to the Global Food Price Crisis (von Braun, 2008) in which it trebled in some countries (FEWSNET, 2010).

Since the 1990s, the region has seen a rapid rise of supermarkets, proliferating beyond middle-class big-city markets into smaller towns and poorer areas (Weatherspoon and Reardon, 2003). They are transforming the food retail sector and, in South Africa, for example, supermarkets already account for more than 55% of national food retail (FAO, 2003). Supermarkets are affecting the food system in two main ways. First, supplying supermarkets presents both potentially large opportunities and challenges for producers as supermarkets' procurement systems involve purchase consolidation, a shift to specialised wholesalers, and tough quality and safety standards. Second, supermarkets are bringing about a change in consumption patterns in the region, with more choice being made available and strong marketing campaigns usually promoting more processed foodstuffs.

Biodiversity and conservation of natural resources

The rich biodiversity in the region helps to support food security both through direct consumption, and via income generated from tourism or commercialisation of *veld* products to buy food (Dube and Sekhwela, 2007). The economic value of wild plants in Southern Africa was calculated to be around US\$269 per household per year, with higher direct use values (Shackleton and Shackleton, 2000). Biomass accounts for four-fifths of the total energy consumption in the SADC region (Yirdaw, 1996). Conservation areas mostly support the predominantly nature-based tourism industry, which is considered a potential future source of foreign exchange earnings for the region. However, despite the potential for abundance and diversity of food and livelihood systems suggested by the rich biodiversity of its natural environment, the Southern African population remains poor and vulnerable to high levels of food insecurity.

In summary, local food production, imports and aid are the main food sources. Economic power determines food production, imports and the level of dependence on food aid. Two systems dominate production, that is, subsistence small-scale and commercial large-scale farming. Food production, particularly in communal areas has either declined or stagnated. Food aid supports the poor and has a major role in periods of disasters. However, regardless of sources of food, storage, handling and distribution are important part of the food system. Distribution and communication networks remain poor within

the region (Arntzen et al., 2004).

Food security in Southern Africa

Southern Africa has experienced a persistent problem of recurring regional food insecurity for many decades. Over the past forty years, since the World Food Summit in the 1970s, this had been driven by a complex interaction of social, economic and physical factors such as rapid population growth; declining per capita food and agricultural production; the poor state of rural infrastructure; failures in domestic macroeconomic and agricultural policies, political instability; widespread poverty, and pronounced climatic variability (Devereux, 2003; Lambrechts and Barry, 2003; DFID/RHVP, 2004; UNICEF, 2008; von Grebmer et al., 2009). In recent years, regional food insecurity has risen further due to a combination of these factors compounded by a set of new stress variables that have had a confounding effect including the AIDS epidemic, weak national systems of governance in the region's emerging democracies and inequitable distribution of land (Drimie and Casale, 2009; Gillespie et al., 2007).

The current Southern Africa food security situation

Two of the key indicators for the rising food insecurity situation in Southern Africa are the rising levels of chronic and severe malnutrition and rates of stunting in children (SADC-RVAC, 2005; UNICEF, 2006; UNICEF, 2008). The number of countries in Southern Africa classified as 'food surplus' has declined over the last decade. This trend is not surprising as *per capita* food production, another key indicator, has stagnated in most SADC countries and even declined in Lesotho, Zambia, Malawi and most recently, Zimbabwe and regional dependence on food aid is increasing (Arntzen et al., 2004; FAO, 2008).

While the region has experienced a modest slow-down in population growth from above 3% per annum in the 1970s and 1980s to an average of 2.7% per annum in the 1990s, population growth continues to out pace the modest 2% annual growth in food production (Bänziger and Diallo, 2001; FAO, 2008). While this net decline in per capita food production is partly met through commercial imports and food aid, in many cases, the vulnerable populations of Southern Africa are simply eating less than the recommended caloric intake for a healthy lifestyle (FAO, 2008).

Current food availability estimates continue to indicate better regional food availability compared to the 2004/05 consumption period (FEWSNET, 2010). However, analyses by national Vulnerability Assessment Committees (VACs) point to growing levels of poverty, exacerbated by the effects of HIV and AIDS, as the main

cause of chronic vulnerability across the region. These findings have prompted national governments and humanitarian agencies to look beyond short-term responses to the food crisis and to develop alternative interventions responding to short-term needs while addressing the longer-term issues in the region (Maunder and Wiggins, 2006; SADC, 2009).

THE CURRENT INSTITUTIONAL AND POLICY RESPONSE

The response to food insecurity has been constrained by weaknesses of national, regional and international institutions. At the international level, agencies have responded late to the food crisis mainly through food aid, despite the evidence of a livelihoods crisis and the need for an integrated response (Drimie, 2004; Mano et al., 2003; Maunder and Wiggins, 2006). At national level, VACs have focused efforts on assessing current food emergencies and planning humanitarian response. Thus, there has been very little strategic policy analysis on ways of stimulating food availability and improving access to food for the poor. Under-informed governments have developed atomistic national food security and famine response policies based on the premise that domestic food crises are primarily caused by local droughts. This has also become politically expedient for countries like Zimbabwe in that rainfall is blamed for hunger rather than the untenable political situation.

In the context of changing environmental conditions outlined previously, the historical tendency of domestic agricultural policy biases to favour the cultivation of import substitution high water-demanding food crops (that is, maize, wheat and rice) in the more drought-prone semi-arid regions of Southern Africa at the expense of drought-tolerant small grains; roots and tubers is particularly insufficient. The overall regional food policy response has been inadequate and incomplete, essentially consisting of consolidated regional requests for humanitarian assistance to avert famine while nations essentially wait for the return of good rains.

Given that coordinated development was the founding principle of SADC in 1984, it is ironic that policy coordination and development cooperation remains elusive. The region still lacks a consolidated regional policy framework for coordinated development of a regional food and agricultural production, distribution and trade system, which would take advantage of SADC's environmental diversity and economic potential. In recent years, SADC with technical aid from its international partners has made some progress in developing regional policy action plans to address the region's food security challenges. While this progress is promising, political will to implement these bold policy declarations continues to lag. For instance, the Lagos Declaration and SADC Plan of Action from the 2004 SADC Summit on Agriculture and

Food Security³ designed to bring about accelerated development of agriculture and ensure food security by committing 10% of the national budgets to agricultural development has not been implemented by most of the many governments who signed the declarations (SADC, 2007).

Environmental aspects are higher on the agenda. The SADC 15-year Regional Indicative Strategic Development Plan (RISDP) of 2004 emphasises sustainable food security and environmentally-sustainable development as key aspects. This latest generation of SADC regional policy plans reflect a paradigm shift towards heightened awareness of environmental dimensions of sustainable development. To be effective, however, the policy declarations must be translated into policy action plans whose implementation is and remains feasible and optimal under a dynamic environment of changing social, economic, political and climatic conditions.

Vulnerability of the Southern African regional food system to GEC

How vulnerable are the region's food systems to GEC and to what extent are they elastic and capable of adapting to anticipated GEC? Answering these questions needs analyses of both how GEC will affect the region's food systems and the importance of these impacts. The analysis must start by recognising that environment is but one of many interacting stresses on the region's food systems. Because of the state of tenuous vulnerability of the food systems, the additional pressure from one stress factor, such as through GEC, impacts the system as a whole. For example, rising poverty in Southern Africa has demonstrated that resource endowment is a necessary but not sufficient condition for food security and prosperity (Thomas and Twyman, 2005).

Multiple stresses on food systems

Over the past two decades, there have been profound transformations in livelihood systems in Southern Africa, set in motion by Economic Structural Adjustment Programmes, the removal of agricultural subsidies and the dismantling of parastatal marketing boards (Bryceson and Bank, 2000). Further, agriculture in Southern Africa faces major challenges including unfavourable international terms of trade, mounting population pressure on land, and environmental degradation (Maunder and Wiggins, 2006; Tadross et al., 2007).

It is important to recognise that food systems, and therefore the food security status they underpin, are exposed to multiple stresses in addition to climate and other environmental changes. Studies of the drivers of

³SADC Heads of State and Government, Extra-ordinary Summit on Agriculture and Food Security, Dar-es-Salaam, 15th May 2004

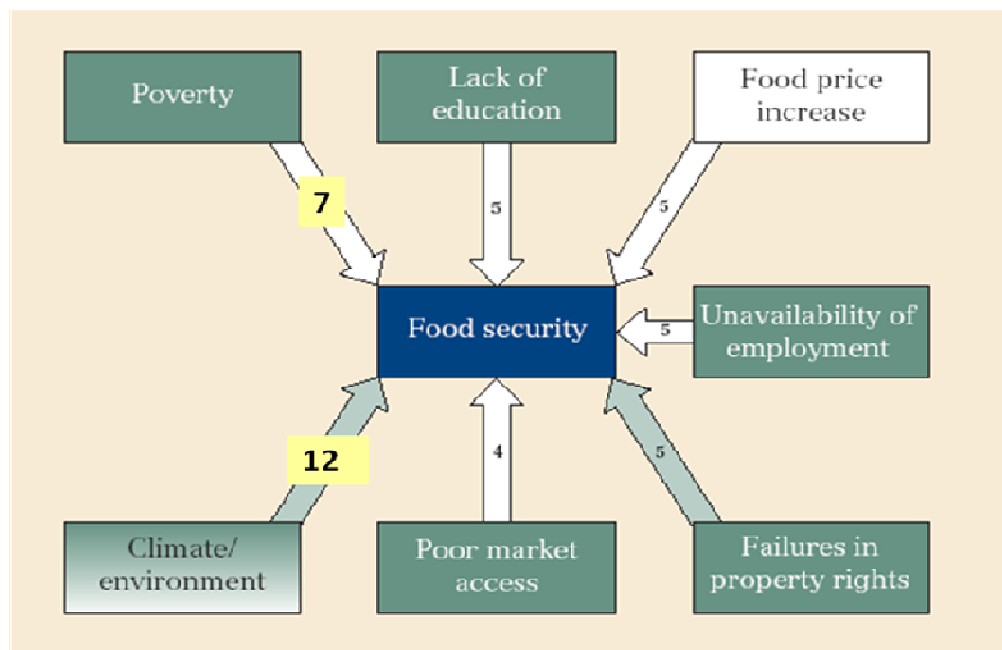


Figure 1. The seven most frequently cited drivers in 49 studies of household-level food insecurity in Southern Africa. The numbers in the arrows indicate the number of citations, as a percentage of 555 citations of 33 possible drivers. The drivers shaded in grey were noted as being chronic, while those in white indicate drivers experienced mainly as “shocks”. The shaded arrows indicate drivers that acted primarily via reductions in food production, while the white arrows indicate those which acted by restricting access to food (Scholes and Biggs, 2004).

household food security in Southern Africa, have found that although the specific combination of drivers varied regionally, common across communities was that vulnerability to food shortages was dependent on a set of interacting factors. Although climate/environment was identified by household respondents as only one of 33 drivers of household food security in Southern Africa, it was one of the seven most frequently cited factors (Figure 1), because of its role both as an on-going issue (57% of cases where it was mentioned) and as a “shock” (43%) (Misselhorn, 2005). Furthermore, the region’s low ability to cope with such shocks and to mitigate long-term stresses means that the employment of coping strategies that might be available to others is at too high a cost or, simply unavailable.

Other issues come into play when looking at food security for the region as a whole. A good example is the poor physical food distribution infrastructure (previously discussed).

GEC as a stress affecting Southern African food systems and security

As outlined previously, food systems and the underlying determinants of food security is complex and include a variety of socioeconomic and environmental factors. To

understand how GEC impacts food security in Southern Africa, we return to the three components of food security: Availability, access, and utilisation of food. GEC most directly affects *availability* through impacts on *food production, storage and distribution*. As demonstrated subsequently, crop, livestock and fisheries productivity is affected by environmental changes resulting from GEC. In addition, extreme weather events affect physical infrastructure, which in turn disrupts food storage and distribution (Liverman and Kapadia, 2010).

GEC affects food availability via production

GEC will undoubtedly affect productivity (that is, yield per unit area). Potential impacts of changes in the climate are well documented for regional crops (Fischer et al., 2001; Jones and Thornton, 2003); and (to some extent) for livestock (Hanson et al., 1993) and marine fisheries (Boyer et al., 2001; Bakun and Weeks, 2004). Maize (the staple crop of the region) yields are projected to decline by nearly 30% by the year 2030; wheat yields may decline by almost 15% (Lobell et al., 2008). Such a fall in agricultural production would have devastating effects across the region (Collier et al., 2008), with particular hardship falling on subsistence producers. A recent pan-African study of climate change impact on African

Table 2. Major Southern African food transport corridors. Derived from SADC-FSTAU, 1993

Coastal country	Name of corridor	Seaport	Neighbouring destinations	Distance to destination (approx. Km)	
Tanzania	Northern Corridor	Dar Es Salaam Port, Tanzania	Mbeya, Tanzania/Malawi Lusaka, Zambia	850 km 2050 km	
Mozambique	Eastern I Corridor	Nacala Port, Mozambique	Blantyre, Malawi	820 km	
			Lilongwe, Malawi	1020 km	
	Eastern II Corridor	Beira Port, Mozambique	Harare, Zimbabwe	620 km	
			Lusaka, Zambia	1110 km	
South Africa	Southern Corridor	Maputo Port, Mozambique	Blantyre, Malawi	1250 km	
			Harare, Zimbabwe	1270 km	
			Durban Port	Harare, Zimbabwe	2070 km
			East London	Harare, Zimbabwe	2370 km
Namibia	Western I Corridor	Cape Town	Harare, Zimbabwe	2460 km	
			Port Elizabeth	Harare, Zimbabwe	2460 km
Angola	Western II Corridor	Luanda Port	Livingston, Zambia	2890 km	
Angola	Western II Corridor	Namibe Port	Malanje, Angola	1700 km	
			Lobito Bay Port	Menogue, Angola	350 km
			Lobito Bay Port	Kuito, Angola	650 km
				584 km	

agriculture concluded that net farm incomes of African farmers are highly vulnerable to climatic variables with estimated elasticity of response to unit degree increase in temperature ranging from - 6 for livestock based farming system, -1.9 for dryland crops and - 0.5 for irrigated crops (Kurukulasuriya et al., 2006). The potential direct impacts of GEC on the region's food production are of concern for several reasons.

First is the prominent role of rainfed agriculture in the livelihoods of many people (Hulme, 1996; IPCC, 1998, 2001). Stige et al. (2006) suggest reduced maize production if the global climate changes toward more El Niño-like conditions, as most climate models predict (maize production in Southern Africa is strongly affected by El Niño events).

Second, soil degradation, already widespread, is rapidly eroding the capacity of the region's ecosystems to support food production (USAID, 2003). It is anticipated to become more severe with inappropriate technologies (Gregory et al., 2002) and more prevalent with expansion of agriculture into more marginal lands (Tyson et al., 2002). Third, water resources are coming under ever greater pressure due to competing demands of urbanisation, industry and agriculture (Schulze, 2005). Fourth, rangeland degradation due to inappropriate management is a growing concern and in particular biodiversity loss. Climate change brings a further concern as this is also likely to change the frequency, intensity, seasonality, and extent of vegetation fires that are critical to the maintenance of major biomes of the region such as *miombo*

woodlands and the *fynbos* of the Cape (IPCC, 2001, 2002; Bond et al., 2003).

GEC affects access to food via biodiversity, prices and livelihoods

The additional concerns about possible GEC-induced losses in land cover, biodiversity and freshwater supplies increase the uncertainty about both agricultural food production and availability of *veld* products. There is a downward trend in *per capita* protein intake (although this is lessened in part by a reliance on *veld* products such as insects, small animals and birds; Scholes and Biggs, 2004). Natural and semi-managed systems are currently relied upon as buffer in drought years (Hulme, 2004; Thomas and Twyman, 2005; Dube and Sekhwela, 2007). As aforementioned, in addition to food production and ecosystem stability, biodiversity conservation in Southern Africa contributes to economic development of the region through nature-based tourism, a potential source of foreign exchange earnings.

It is known that *food access* is affected by changes in food prices (Liverman and Kapadia, 2010). Concomitant to this is the role of livelihoods stability and development in ensuring access to food. These determinants are also indirectly impacted by GEC. With the prospect of declining food production and disruption to food storage and distribution as a result of GEC, demand may surpass the supply of food, with the consequence of rising food

prices. GEC has the potential to exacerbate widespread poverty in much of Southern Africa via impacts to livelihoods dependent on natural resources and healthy ecosystems such as farming and nature-based tourism. Arguably, a link can be described between all stresses and all components of food security if one considers n^{th} order interactions. "Mapping" first order interactions is valuable in helping to identify where adaptive strategies may best be targeted. Some examples are given in Table 2.

The varied manifestations of GEC are not acting in isolation of one another, or in isolation of the socio-economic stresses that increasingly affect the region. The interactive impacts of these stresses will have far reaching consequences for the region's future food security. Understanding how they interact with the food system is necessary to help devise more effective and viable adaptation strategies that both boost socio-economic development and minimise further environmental degradation.

Vulnerability of the Southern African food system in light of policy limitations

The study have already demonstrated the complexity of food systems and security in Southern Africa, wherein access, availability and utilisation of food is dependent on interacting economic, social, political and environmental factors. Although the region has the capacity to produce sufficient food under current conditions, inadequate development and implementation of integrated, coordinated and comprehensive regional policies limit access and availability to impoverished populations in the region. Lack of infrastructure and ongoing environmental degradation contribute to the region's low ability to both mitigate long-term stresses and cope with external shocks brought about through GEC. The addition of GEC to an already strained regional food system and fragile environmental conditions enhances the need for a regionally- integrated and forward-looking food system strategy that: Acknowledges present biophysical and policy opportunities and constraints in all three components of food security (availability; access; and utilisation of food); and that recognises potential future integrated scenarios of future socioeconomic and environmental conditions.

The Predictable Effects of Developments/ Dynamics on Food Security

A critical examination of the current food system of Southern Africa shows a poorly-integrated food production and marketing system already constrained by incomplete regional food market institutions, a highly concentrated and inadequately distributed density of transport, communication and storage infrastructure. The prospect of climate change shifting the geographical

distribution of agricultural and food production potential raises the question of whether the region's skewed-distributed and poorly developed infrastructure will be able to cope. This paper has outlined: the complexity of South African food systems and resulting food security; current gaps and limitations of the policy response to address these underlying determinants of food security; and the mechanisms through which GEC exerts pressure on already strained food systems, thereby threatening food security in the region. The additional pressures of GEC aside, it has been demonstrated already that the general policy and strategic response has failed to strengthen regional food systems and to address underlying determinants to food security such as poverty reduction and livelihoods development. In light of GEC-related challenges to regional food system stability and established policy gaps, the following recommendations support the development of a sustainable and comprehensive regional food security strategy.

RECOMMENDED POLICY AND STRATEGIC FOR ENHANCING SOUTHERN AFRICAN FOOD SECURITY IN THE CONTEXT OF GLOBAL ENVIRONMENTAL CHANGE

Increase food production

Here, the findings from the extensive review and consultations are drawn together in order to develop recommendations for such a strategy within SADC, in particular those based within the Food, Agriculture and Natural Resources (FANR) Directorate. Research investment is increasingly being targeted towards "technical" agronomic, options for maintaining and hopefully increasing, agricultural food production in the face of GEC. Production increases can also be achieved by policy instruments such as water pricing (which encourages water use efficiency). Another option is to introduce national grain marketing boards (as seen in Zimbabwe before and after independence, Buckland, 1993) which when efficiently operated offer producers a guaranteed market and minimum price thereby encouraging increased production.

However, when implementing different technologies, and especially those aimed at intensification, it is important to consider the environmental consequences of different approaches; the degree of intensification (based largely on the quantity and efficiency of use of external inputs) has different on- and off-site environmental consequences for soils, water quantity and quality, and climate forcing and regional climate change (Gregory et al., 2002).

New technologies also often have social and/or economic constraints, which need to be considered. For instance, one of the major characteristics of early-maturing and high-yielding hybrid crops such as maize (promoted to cope with drought and the low-production

constraints of local and other varieties) is increased demand for inputs. These are expensive and inaccessible by the majority of farmers and many recycle hybrid seed and produce maize without application of fertilizer thereby missing much of the benefit of the new technologies (Mharapara et al., 2005). This is further limited by the immense challenges of meeting the increased demands for inputs for this kind of farming. Another approach is to develop policies that support greater reliance on *veld* products as opposed to conventional agriculture. As noted previously, *veld* products are a significant food source, especially in times of stress, and most of the sources of such products are better adapted to the climate than major crops (e.g. maize) and some might even be favoured under climate change (Dube and Sekhwela, 2007). This idea is developed further in Von Maltitz et al. (2007), who argue that to protect biodiversity under climate change there will be a need to focus on managing areas (such as rangelands) outside protected areas because this is where greater diversity of species occurs (Scholes et al., 2004). This can be achieved through devolution of resources ownership and management to communities, securing community tenure rights and incentives for economies based on veld products as opposed to conventional agriculture.

Food production is clearly important, as it is directly impacted by GEC, but food storage and distribution, and exchange also determine food availability.

Improve food storage and distribution

Food availability can be increased by having a sufficiently-large amount of food in storage to offset the effects of, for instance, a drought year. However, due in part to poor transport and communications infrastructure in the region, current food storage systems cannot hold adequate food to compensate for time delays it takes to import food into the region. Damage to infrastructure is expected to increase, as the existing infrastructure is not built to deal with more frequent and severe floods.

A region-wide agreement on food storage would be of great benefit but it would require considerable political and financial commitment, and the pros and cons of a few large stores vs. many small stores would have to be considered.

Improve intra-regional trade

An improved intra-regional trade arrangement would facilitate food exchange within the region. Currently however, trade barriers and lack of harmonisation of trading systems are a serious constraint to food movements across borders. These constraints include different tariff structures, different physical transport requirements e.g. axle weight restrictions and vehicle size restriction across borders. These and other non-physical constraints

including lack of a cohesive and harmonised set of trade policies add to the stressors in food system. The region has great potential to meet its own food needs but one of the biggest stumbling blocks to achieving this is lack of trust and meaningful cooperation amongst SADC.

Improve food access and utilisation

A range of technical and policy approaches have been identified to adapt those parts of the food systems that contribute to the food available component of food security at region-level, through production, distribution and exchange. The primary challenge posed at both the scale of natural resource management and at the scale of international agreements and actions is to promote adaptive capacity in the context for competing sustainable development objectives.

Valuable though these might be, food security also depends on access to food and food utilisation. Fewer adaptation possibilities have been considered to address these aspects, despite the fact that there are several major food system stresses that have a first-order impact on these components (Table 3). Some adaptation options fall into the technical category, e.g. fortified crop varieties relating to nutrition. Most however are more primarily related to either economic issues (e.g. affordability) or social and political issues concerning the social function of food. Campaigns to increase the production of more drought-tolerant food is being implemented without a thorough appreciation of food habits of target communities; maize has become the dominant source of food to the extent that alternative sources of nutrition such as cassava and sweet potatoes are treated as snacks. Changing public attitudes via media campaigns would be required as part of an overall strategy.

Develop and implement a regional research strategy

A regional strategy will require ongoing, innovative research to ensure that the dynamic interactions between GEC and food systems are understood and anticipated. The growing concern that GEC will further complicate achieving food security has been noted in a number of consultative meetings involving regional researchers, policy makers and donors (GECAFS, 2006). However, as outlined previously, the interactions among GEC and food systems are complex and need to be better analyzed to assess the implications.

There is also concern that meeting the region's rising demand for food will further degrade the environment (Tyson et al., 2002; Gregory et al., 2002) due to increased exploitation of land, water, plant and animal resources, if careful and appropriate management is not in place (Scholes and Biggs, 2004). This will likely, in turn, further undermine the food systems upon which food security is based. Reversing this negative cycle is

Table 3: Impacts of example stresses on different aspects of Southern African food systems.

	Availability	Access	Utilisation
Climate variability	✓		
Water stress	✓		✓
Transport Infrastructure	✓	✓	
HIV/AIDS	✓	✓	✓
Monetary policies		✓	
Food Retailing Policies/Trends		✓	
Urbanisation/Migration		✓	
Information			✓
Unemployment		✓	✓
New Technology	✓		✓

key to sustainable development in the region, but there has to date been limited capacity to generate policy relevant information to address GEC effects for development agendas.

Clearly, the region's food production systems will need to change in alignment with the anticipated changes in climate and other important environmental factors. Current research efforts need to be complemented by approaches that consider the larger set of interactions between GEC and the food system as a whole.

Develop and support a regional policy perspective

Many of the more economic- and policy-related strategies for adapting the region's food systems may be most effective if approached from the perspective of the region. This is because food security planning in the context of GEC can be particularly effective at this spatial scale. First, climate and weather-related perturbations are often experienced at the sub-continental scale and adaptation strategies may be applicable across more than one district or nation. Second, the adaptation strategies themselves may prove most effective if managed at the regional level, in terms of improved intra-regional trade, food storage and transport facilities. Third, some environmental management issues only manifest at this spatial scale (e. g. water resource depletion) and solutions to such problems may often require supra-national considerations.

Fourth, designing policies at this scale means that they can capitalise on the heterogeneity of the region by balancing areas better endowed with natural or human resources with those less well endowed. Fifth, there is already a mechanism in SADC to debate, devise and implement policy at the regional scale and which can bring together planning at national level and help this to interact with regional organisations addressing biodiversity conservation, human wellbeing, water resources

or local governance (ICLEI, 2006).

Support interdisciplinary research for regional policy formulation

There is a need to frame and execute research addressing both activities and outcomes of food systems within a GEC context. A major emphasis of climate change/food security research has addressed the agronomic aspects of climate change, and particularly crop yield. Socioeconomic and biogeophysical factors need to be integrated within an interdisciplinary research approach that recognises the interconnectivity between policies at different spatial and temporal scales.

Such studies need to build on the wealth of disciplinary studies which have characterised most GEC and food-related research to date. New research needs to set new agendas addressing emerging issues for interdisciplinary science related to food security and sustainable development. This in turn requires a novel approach to organising research (Quinlan and Scogings, 2004).

Conclusions

Better governance in relation to GEC needs to be built on the three-way links between science, policy and practice. This is particularly important for food security issues in Southern Africa, where GEC is anticipated to have significant impacts. Policy, and particularly relating to a regional perspective, needs to be founded on innovative research that builds on, and integrates the wealth of disciplinary studies and development projects in the context of policy information needs. However, results from GEC scientific endeavours have not, to date, often been adopted by the policy community. This is because the GEC research agenda related to food security in Southern Africa (as elsewhere) has not been well linked with the development agenda, despite the fact that

development goals and improved environmental management are often closely related.

GEC/food security research aimed at supporting policy development must provide practical assistance to evaluate options for reducing vulnerability of food systems to GEC. It therefore needs to be aimed at assisting the region's policy makers and planners to develop a better perspective on responses. This needs a strong participatory process as the guiding philosophy at all stages of research planning. This paves the way for fruitful collaboration during the implementation phase. Research planning must therefore ensure that the wide range of regional policy-making institutions, researchers and development practitioners engaged in the planning stage continue to be involved in the research implementation and policy development cycle. This will ensure timely and strategic feedback of scientific research output to regional policy and planning activities.

Whether addressing food security issues related to food availability, food access or food utilisation, resilience to the additional stresses GEC is bringing needs to be built systematically into new projects and policies (Toulmin, 2005). To be truly of mutual benefit, the agenda needs to be addressed as a collaborative effort between social, economic and environmental sciences and the policy and practice communities operating at a range of scales. Basing dialogue on a regional scenarios approach would help achieve this.

ACKNOWLEDGMENTS

The authors gratefully acknowledge: Funding for discussions leading to the preparation of this paper from the UK's Natural Environment Research Council, US NOAA Office of Global Programs and US Agency for International Development; the intellectual input of many regional participants in these meetings; and the assistance of Sophie Paterson in preparing the manuscript. This paper is a contribution to the international research project "Global Environmental Change and Food Systems" (www.gecafs.org), and is derived, in part, from discussions culminating in the GECAFS Southern African Science Plan and Implementation Strategy (GECAFS Report No. 3).

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