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Global environmental change and the dynamic challenges facing food security policy in Southern Africa

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Abstract

Food insecurity in Southern Africa is increasing. Key indicators are the rising levels of chronic and severe malnutrition and rates of stunting in children. There is growing concern that Global Environmental Change (GEC) will exacerbate the stress on Southern African food systems leading to increased food insecurity in the region. 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. These need to be set in the context of regional socioeconomic and environmental conditions. Initially, a better understanding of how the region's food systems operate and the policies that affect them is needed. This will provide a foundation for identifying and assessing the when and how food systems are vulnerable to the additional potential stresses that GEC will bring, and thereby for exploring possibilities to strengthen their resilience. Further research issues revolve around the interrelationship of consequences of policies set at regional and national scales.

Key words: Southern Africa; food security; GEC; policy formulation; food systems

1. Background and objectives of the paper

Global environmental change (GEC) is happening. 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. These include changes in freshwater supplies, carbon and nitrogen cycling, biodiversity, and land cover and soils (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). 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. These concerns are particularly pertinent to Southern Africa where food insecurity is already a major issue and projected impacts of GEC are particularly severe (Arntzen et al., 2004).

The objectives of this paper are two-fold. First, it highlights how GEC is adding additional stress to Southern Africa's currently fragmented, fragile and under-developed regional food systems, thereby further undermining regional food security. Second, the paper argues for the adoption and implementation of a stronger and wholesome 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. This is especially needed given the absence of an integrated regional strategy to enhance the prospects for regional food security in the context of GEC.

2. Food security in Southern Africa

Southern Africa has suffered from a persistent problem of recurring regional food insecurity for many decades. Historically this has 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, national and regional institutional rigidities; political instability; widespread poverty; and pronounced climatic variability. In recent years, regional food insecurity has risen further due to a combination of these traditional factors compounded by a set of new stress variables that have had a confounding effect on food security at all levels. These include the HIV/AIDS pandemic, weak national systems of governance in the region's emerging democracies, inequitable distribution of land resources and premature globalization of regional food systems.

The current Southern Africa food security situation

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). Additionally, six of the nine Southern African countries are classified as "medium" to "low" in terms of the Human Development Index, while eight are listed among the poorest 20 out of all developing countries in terms of the Human Poverty Index (UNDP, 2005). 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 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). Five of the 14 SADC countries are presently included in the current UN World Food Programme's Protracted Relief and Recovery Operation, with a total of 8.2 million people receiving food aid in January 2006 (WFP, 2006b).

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 – due in part to the rise in HIV/AIDS-related deaths and successful family planning efforts – population growth continues to out pacing the modest 2% annual growth in food production (Bänziger and Diallo, 2001). 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 is simply eating less than the recommended caloric intake for a healthy lifestyle. Poor economic performance confounds the food security situation of these Southern African countries as they cannot afford commercial imports to fully offset shortfalls in domestic food production. It is meanwhile becoming increasingly difficult for the WFP and humanitarian organisations to secure adequate volumes of food aid to fill the gap between food security requirements and aggregate food availability in African countries experiencing famine. In 2004, famine-hit Southern African countries were only receiving 60% to 80% of official humanitarian requests (Mano et al., 2003). In 2006, the Southern African region's request for 2 million tons of food aid has had lukewarm response from traditional partners as donor fatigue appears to have hit Western countries increasingly overwhelmed by the rise in global humanitarian disasters.

The period 2002-2003 saw the worst food crisis in Southern Africa since 1992. The 1992 crisis was mainly due to drought. While drought certainly also played a role in 2002, the crisis was significantly deepened by a number of other factors which grew more prominent over the decade including structural imbalance, poor governance, socioeconomic decline and HIV/AIDS. Poverty and food insecurity are now on the increase in Southern Africa, seriously compounded by a worsening HIV/AIDS situation. This has resulted from a range of "entangling crises" (Devereux, 2003; de Waal and Whiteside, 2003; Lambrechts and Barry, 2003; Zimbabwe-VAC, 2003; DFID/RHVP, 2004). In general, while the food crisis of 2002-2003 was triggered by the unavailability of food, the problem has been recognized to be more of access and entitlements for most of the affected people (DFID/RHVP, 2004).

Current food availability estimates continue to indicate better regional food availability compared to the 2004/05 consumption period. However, recently-completed household-level vulnerability assessments in the countries adversely affected by the poor performance of the rainy season reveal widespread levels of food insecurity among vulnerable groups. The total number of food insecure people requiring humanitarian assistance in the region is estimated to be over 10 million people: 5.0 million in Zimbabwe, 2.5 million in Malawi, 1.0 million in Zambia, 800 000 in Mozambique, 550 000 in Lesotho; 245 000 in Swaziland, 111 000 in Namibia, 1.6 million in Angola (WFP, 2006a). Analyses by national Vulnerability Assessment Committees (VACs) point to growing levels of poverty, exacerbated by the effects of HIV/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.

The current institutional and policy response

The response to the food crisis in Southern Africa has been constrained by weaknesses of both 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). At national level, Vulnerability Assessment Committees (VACs), originally established to provide strategic intelligence understanding of the national food security situation in the region, have instead focused their efforts primarily on assessing current food security emergencies and planning the 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 of Southern Africa have developed atomistic national food security and famine response policies based on the premise that domestic food crises are primarily caused by local droughts. Thus the overall regional food policy response to the regional food crisis 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 in the regional community. The SADC 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. Although SADC countries ratified a free trade protocol more than ten years ago, the regional body ran short of political will to implement it. Yet regional trade studies commissioned by the secretariat and international financial partners show that free regional trade would significantly enhance regional economic growth and regional food security by eliminating localized climatic and market risks (COMESA, 2003; FAO, 2003a; FANRPAN, 2004; IFPRI, 2004; Imani, 2004). 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 massive food security challenges. While this progress offers hope for meeting some of the Millennium Development Goals (MDGs), political will to implement these bold policy declarations continues to lag far behind. For instance, the Lagos Declaration and SADC Plan of Action from the 2004 SADC Summit on Agriculture and Food Security[1] 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.

Environmental aspects are however 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 within the SADC Secretariats of environmental dimensions of sustainable development and long term strategies for combating food insecurity in the region. 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 circumscribing the region's food security situation. A critical examination

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

of 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 poorly distributed density of transport and communication, 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 skewly-distributed and poorly developed infrastructure will be able to cope.

3. 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 (eg conflict, declining per capita investment expenditure in agricultural research and development, anticipated changes in global food market situations and trade protocols, current HIV/AIDS, tuberculosis and malaria epidemics). 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, 2006). *Activities*, which relate to the production, processing, distribution, preparation and consumption of food; and *outcomes* of these activities, which contribute to the three components of food security: availability of food; access to food; and food utilisation. 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. In strategic terms, two categories of agricultural producers are commonly distinguished within the region. There is a minority population of modern, highly sophisticated commercial farmers, producing a diversity of market-oriented crops and livestock purely to maximise their profits. Since profit maximisation also necessitates minimisation of costs, the African commercial farmers apply the best available agricultural technologies and choose to produce a mixture of food and non-food commodities offering highest returns to their land and capital resources. The majority of the agricultural producers in Southern Africa are however poor, indigenous populations practicing semi-subsistence agriculture driven in their farm operations by a desire to secure a satisfactory and secure livelihood. Thus their farming system is 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 indigenous farming population has long demonstrated a willingness to diversify and expand production of surplus food for the national and regional markets in response to market incentives and provided that such commercial ventures help mitigate reduce risks and increase livelihood security.

Key characteristics of each category are summarised in Table 1. 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) are now being abolished. In Zimbabwe land re-distribution policies have resulted in a significant reduction of commercial farmers.

[Table 1 : Key characteristics of subsistence and commercial producers.]

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 from the data for the period 1990-2003, but the share of maize is increasing slowly, mostly at the expense of wheat production. 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 1990-96 (excluding the 92/93 drought) to 22.5 million tonnes in the period 1997-2003. There are however marked national differences. The total potential agricultural area in Southern Africa is heavily under-utilised, with only 20% of the suitable land under cultivation. The irrigation sector is small in most countries (except for South Africa and Zimbabwe) and only covers 4% of cultivated land (Stilwell, 2000). Livestock is a major production activity in the region, totalling 0.4 Mt in 2004 (FAOSTAT, 2005), and contributes to subsistence systems across the region and also to the national economies of South Africa, Botswana, Namibia and Lesotho. Fisheries are also important with 2.6 and 0.7 Mt landed by SADC countries in 2003 for marine and freshwater fisheries, respectively (FAOSTAT, 2005).

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 6 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 (see Table 2). Furthermore, in all cases there are a number of transhipment points, e.g. the use of ferries between Namibia and Zambia at Katima Mulilo in the Caprivi Strip, transhipment of cargo between the Tanzania-Zambia Railway Authority (TAZARA) and Tanzania Rail Corporation due to differences in rail gauges, rail to road transhipments in Harare for cargo destined for Malawi, etc. These cause additional stressors to the already poor food transport networks.

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

The scattered pattern of rural settlements in much of the region leads to a low density of road networks, ranging from 0.01 - 0.47 km of road per km^2. This is far below the 0.30 - 0.45 km per km^2 in many Asian countries (Stilwell, 2000) and Zimbabwe and South Africa are the only countries with road densities similar to the Asian averages. In Mozambique and Zambia, for example, the road network is so poorly developed that it is more efficient to import food through the main road and rail trunks than to move food within the country.

The 36 000 km railway network in Southern Africa spans all countries except Lesotho and constitutes over 70% of all Africa's railways. The railway conveys over 200 million tonnes of traffic per year although its estimated capacity is 350 million tonnes per year (Mlenga, 2003). Competition between road and rail transport has become a major issue during the past few decades. The development of modern road vehicles, and in particular, large truck-tractor and trailer combinations, has brought the rail mode of transport into disfavour by many transport users who require ever-faster services and often rely on just-in-time delivery principles to keep warehouse stocks low and minimize cash up-front interest charges (RASS, 2006). This will have a significant bearing on the ability to move food quickly around the region in times of stress, especially if road infrastructure is weakened due to weather extremes.

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. In 1993 these grain storage facilities in SADC countries were estimated at 8.5 million tons (SADC–FSTAU, 1993). 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 1992-93 crisis due to little additional capital expenditure in storage infrastructure. This is despite the fact that the private sector is now providing storage facilities following market liberalisation systems introduced in most countries in the early- to mid-1990s.

An attempt has been made by the region to develop a regional food grain reserve to help alleviate food insecurity, especially in drought years. Since the 1980s, SADC has considered the establishment of a strategic food reserve to deal with the growing frequency of natural disasters. Early proposals were based on considerations of enough physical maize stock for 12 months consumption. Despite this, most government reserves were at record low stocks at the 2002/2003 marketing year (Mano et al., 2003). The SADC Council of Ministers have recently agreed that the food reserve proposal should be re-visited and should include consideration of both a physical reserve and a financial facility, supporting the notion of enhanced intra-regional trade.

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 and millet are very small, and confined to a few countries (Botswana, Zimbabwe and South Africa). The costs of imports fluctuated between 30-55 US$ million in the period 1994-2003, but no trend is apparent. The import bill during the 1992/93 drought exceeded US$100 million.

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. Koester concluded that grain production does not only reflect local environmental conditions but also revealed preferences of policymakers in each country (e.g. maize in Zimbabwe) as well as trade policies adopted by each country.

Informal cross-border trade continues to play an important role in filling some of the import requirements, especially in Malawi which has so far received close to 75% of the total amount of maize traded informally in the region (WFP, 2006b). 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 a lack of a cohesive and harmonised set of trade policies, exacerbate problems of food distribution.

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. The region's current need for food aid is estimated at 446 000 tonnes for 9.2 million people by end of May 2006 (FEWSNet, 2005).

Where countries or consumers cannot afford to purchase food the need for food aid will grow, and become more frequent as GEC accelerates. 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. In recent years, Southern Africa has failed to secure adequate and timely response to official food aid requests with some countries receiving as low as 60% of official requests (IRC, 2005) in 2005. Externally procured deliveries of food aid have also clogged the limited port facilities in South Africa and Mozambique as well as the inland rail and road transport system culminating in disruptions in food aid supplies to famine hit populations.

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, but still remained 45% below the November 2004 high point.

The last decade has seen a rapid rise of supermarkets in the region, 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 percent of national food retail (FAO, 2003b). Supermarkets are affecting the food system in two main ways. First, supplying supermarkets presents both potentially large opportunities and big challenges for producers as supermarkets' procurement systems involve purchase consolidation, a shift to specialised wholesalers, and tough quality and safety standards. Making the necessary investments and adopting new practices is hardest for small producers, who risk exclusion from dynamic urban markets increasingly dominated by supermarkets. 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.

In summary, local food production, imports and aid are the main food sources. Economic power determines food production and imports and the level of dependence on food aid. Two systems dominates production, i.e. 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. While the region has adequate grain storage facilities, distribution and communication networks remain poor (Arntzen et al., 2004).

4. Current and anticipated environmental conditions

Are the region's food systems best adapted to make optimum use of the region's diverse range of biophysical resources and environmental endowments? The domestic agricultural policy biases have historically favoured the cultivation of import substitution high water-demanding food crops (i.e. 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. Strategies for adapting food systems need to be considered in the context of current and anticipated environmental conditions.

Current environmental conditions

Southern Africa has a diverse climate ranging from humid coastal zones to land-locked (semi-) arid lands. It is marked by high intra-seasonal and inter-annual variability both of which influence food systems in the region. Rainfall levels and variability vary enormously within the region with the driest parts in the southern central to western parts of the region and wetter conditions with more reliable rainfall towards the north. The highly variable climate regime is due partly to the El Niño Southern Oscillation phenomenon (Tyson et al., 2002). Severe droughts of the 1980s and 1995 (which led to a serious decline in food security in the region) and the floods of 1999/2000 (which resulted in a decrease in GDP growth rate of Mozambique from 10% to 2%) are good examples of such extreme events. Droughts of various magnitudes occur as frequently as every 2-3 years in the driest parts covered by Botswana and Namibia. Generally there is an east to west rainfall gradient in the region linked to the warmer Indian ocean in the east resulting in relatively higher rainfall and the cold Benguela current in the west accounting for the arid to semi-arid condition. Rainfall also

declines from the north in relation to the Inter-Tropical Convergence Zone (ITC) and the Atlantic Ocean Air masses (Tyson et al., 2002; Scholes and Biggs, 2004).

Much of Southern Africa is covered by infertile soils due to a predominantly granitic geology (Scholes and Biggs, 2004). The central parts of the region, stretching from the northern part of South Africa, over most of Botswana to the Democratic Republic of Congo is covered by the nutrient poor well-drained, aeolian Kalahari sands which are not suitable for crops with high water demand such as maize. Pockets of fertile soils are limited to drainage networks associated with the southern extension of the East Africa rift valley.

The region has several large river basins including the Zambezi (1.4 Mkm^2) and Limpopo (385 000 km^2) (Sharma et al., 1996; Boroto, 2001). Seven out of the nine countries share multiple international river basins (typically four to nine per country) and, given the growing water demand, this has major implications for water governance and general catchment management for food production activities (Sharma et al., 1996). The region has responded by establishing the Shared Water Resources Protocol. At the basin level the focus is on establishing joint water commissions and institutions to manage individual watercourses and water development projects collaboratively. At the regional level, the protocol offers a general framework for creating joint water-resource networks and policies based on both UN Convention principles and existing regional institutions. SADC has provided the umbrella for drafting the Water Protocol in the region (Scholes and Biggs, 2004).

The distinct dry and wet season climate of the region supports a variety of biomes (grasslands, *miombo* woodlands, dry savanna, desert and arid shrubland vegetation, and limited areas of wetlands, *fynbos* and forest) rich in wildlife resource that form an important part of income generation and food systems of the region. In some countries a significant proportion of the land is under wildlife conservation areas (e.g. 17% of the total surface area in the case of Botswana; Moyo et al., 1993) and these are essential for the tourism industry. The biodiversity of the region is high in both species and ecosystems types: The fynbos of the Cape Floral Kingdom which occupies only 37 000 km^2 at the southern tip of Africa, has 7300 plant species, of which 68% occur nowhere else in the world and the adjacent Succulent Karoo biome contains an additional 4000 species, of which 2500 are endemic (IPCC, Chapter 10-Africa, 2001).

Anticipated GEC in Southern Africa

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 2-5°C predicted over coming decades (Hulme et al., 2001; IPCC, 2001, Chapter 10-Africa). An increase in extreme events (both droughts and floods) is also anticipated (IPCC, 2001; Tyson et al., 2002), as is 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. The rate of deforestation in the region was estimated at 0.9% per year in 1993 (Yirdaw, 1996). Despite the fact that national research institutions, in collaboration with CGIAR Centers and other international programmes, have developed best bet natural resources management technologies

implemented through community based organizations, the rate of land degradation in many Southern African countries is faster than the speed of technology adoption.

About 168 million hectares burn annually south of the equator and this amounts to 37% of the dry biomass burnt globally (Goldammer and de Ronde, 2004). Southern Africa provides a conducive environment for fire with the distinct dry and wet seasons; rhythms of drought followed by wet years; rainfall marked by thunderstorms and lightening and extensive area under the tropical savanna characterised by grassy under storey (Pyne et al., 2004). Results of satellite-based fire monitoring reveals that more than half of Africa experiences a fire regime with a frequency greater than once per decade (Kendall et al., 1997).Climate change is likely to alter fire regimes with consequences for global and regional climate because emissions and aerosols from vegetation fires in Africa constitute a significant contribution to the global budgets (IPCC, Chapter 10 Africa, 2001).

Issues of water availability are also a growing concern, 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, as it would require expensive purification. Further, most of the underground water is fossil resource and the estimated recharge for the region is at 1% or less of the mean annual rainfall (Xu and Beekman, 2003) which is far below the extraction rate. (Water conservation measures are largely non-existent in most parts of the region and, where available, are not effectively applied.) 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 (Scholes and Biggs, 2004; de Wit and Stankiewicz, J., 2006). Sub-optimal catchment management is leading to increasing siltation of water reservoirs and deltas with other downsteam 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). Competition over water resources is increasing, for instance livestock versus wildlife interests as seen in the Okavango Delta in Botswana (Dube, 2003).

5. Vulnerability of Regional Food Systems to Global Environmental Change

How vulnerable are the region's food system 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 however start by recognising that environment is but one of many stresses on the region's food systems. Rising poverty and food insecurity in Southern Africa demonstrated that resource endowment is 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 therefore faces major challenges including unfavourable international terms of trade, mounting population pressure on land, and environmental degradation. These and other current and emerging stressors for Southern

African food systems can be divided into three major categories: (I) natural resources; (II) physical infrastructure (i.e. man-made); and (III) institutional and other "human dimensions" issues. These can be sub-divided into at least seven sub-categories: (i) environmental (e.g. droughts, floods and other climate-related aspects, land degradation and desertification); (ii) infrastructural (e.g. reduced investment in railways, port facilities, road networks, grain storage facilities); (iii) institutional (e.g. poor regional cooperation); (iv) socio-cultural (e.g. HIV/AIDS, unemployment); (v) economic (e.g.: price fluctuations, asset loss); (vi) demographic (e.g. urbanisation); and (vii) political.

While the main emphasis of this paper is GEC, 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. For example, in studies of household food security in Southern Africa, climate/environment was only one of 33 drivers mentioned as important by householders (Misselhorn, 2005). The mix of drivers varied across the region but in all communities many interacting factors resulted in vulnerability to food shortages. Overall, however, climate/environment was one of the seven factors influencing food security that were frequently cited (see Figure 1), because of its role both as an on-going issue (57% of cases where it was mentioned) and as a "shock" (43%). The impacts of sudden shocks such as drought are therefore felt on top of ongoing long-term stresses. 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.

[Figure 1: The seven most frequently cited drivers in 49 studies of household-level food insecurity in Southern Africa.]

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 (discussed above), which increases vulnerability of the region's food systems to GEC especially in times of food crisis. Similarly, storage capacity is not capable of holding sufficiently large stocks to provide food for the region when the next major drought occurs. With limited budgets, little policy priority is given to the food systems physical support infrastructural systems. The availability, state and condition of food systems physical support infrastructure for both the production and distribution of food within national and across national boundaries in the region are in a poor state. Issues of this type warrant serious attention by policy bodies mandated to work at nation and regional scales.

GEC as an important further stress affecting Southern African food security

GEC and food security was identified as one of the top priorities for Africa by the recent AFRICANESS workshop[2]. Given the socioeconomic and GEC issues discussed above, the food security situation is however particularly critical in Southern Africa; GEC is already adding further stress to what is already a complicated food security situation for many (Misselhorn, 2005).

GEC will undoubtedly affect productivity (i.e. yield per unit area). Potential impacts of changes in the climate are well documented for regional crops (Fischer et al., 2001; Jones and

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

Thornton, 2003); and (to some extent) for livestock (Hanson et al., 1993) and marine fisheries (Boyer et al., 2001; Bakun and Weeks, 2004). The impacts of GEC on maize production is clearly of critical importance to the region, while other staples will not be as significantly impacted (e.g. rice and wheat are mostly imported). A recent pan-African study of climate change impact on African 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). Ironically, but for very strong agroecological and socio-cultural reasons, the more drought-resistant grains such as sorghum and millet are the least important at the regional level, with production principally currently confined to the semi-arid areas. Similarly, irrigation and managed water based farming systems most resilient to temperature and precipitation changes are also the least developed in Southern Africa. 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) and it 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. Amongst the basic premises made are that the hydrological system amplifies any variability in climate, that different components of the hydrological system differ markedly in their responses to rainfall variability, that streamflow variability is considerably higher in external than in internal (mainstem) sub-catchments, that land use change often increases flow variability and that degradation of the landscape amplifies further any hydrological responses (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). Extreme events, particularly where these occur in the form of above-average rainfall supporting large fuel loads, are likely to culminate in fierce fires when immediately followed by periods of dry, hot and windy weather (Rutherford et al., 1999). Changes in disturbances such as fires can interact with climate change to affect biodiversity via for example, ecosystem switches from indigenous vegetation communities to highly flammable fuels (Bond et al., 2003). This is likely to result in loss of habitat and will threaten livelihoods dependent upon the associated biodiversity.

Rising poverty and food insecurity in Southern Africa demonstrated that resource endowment is necessary but not sufficient condition for food security and prosperity. 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, in press). Widespread fire and deforestation of *Mophane* woodland for

example, is a threat to the reproductive capacity of *Mophane* caterpillar *veld* product, which is a nutritious source of food and income over Botswana, Malawi, South Africa, Zimbabwe and Zambia (Dube and Sekhwela, in press). 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). While conservation areas mostly supports the predominantly nature based tourism industry which is considered a potential future source of foreign exchange earnings for the region. Nevertheless, 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.

Even without the added GEC dimension, links between food security and environment are therefore of great importance for Southern Africa. About 70% of the 200 million people in the region rely on their immediate environment for food security, either from agricultural activities and fisheries, or from *veld* products; and over 80% rely on biomass energy (Yirdaw, 1996). Despite this high reliance, high population growth (2.1% on average over 1990-2002; SADC RISDP, 2004), low and volatile economic growth (3.2% in the period 1990-2002, with a range from 1.5% in 1999 to a peak of 3.2% in 2002 (SADC RISDP., 2004) combined with poor environmental management policies are resulting in the depletion of key land resources.

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, in press). The region's rich biodiversity is under threat from increasing demand due to rapid population growth, widespread poverty, commercialisation of natural resources combined with poor land resource governance. Vegetation degradation reduces the value of the region's natural resources for both *veld* food products and tourism, which both impact negatively on livelihoods.

Despite the concerns reflected in the international GEC literature and from various UNEP programmes, GEC is not a priority in regional or national development plans in Southern Africa. With a few exceptions (such as DFID and USAID) GEC is rarely reflected in development policies and plans addressing food issues. This is due to a number of factors: a pre-occupation with responding to short-term priorities and emergencies; a lack of resources; and limited appreciation of the significance of GEC for sustainable development, resulting from lack of policy-relevant information on the interactive effect of GEC and food security (Arntzen et al. 2004). Further, food issues have been treated in a fragmented manner by different GEC international research initiatives.

The varied manifestations of GEC are not acting in isolation of one another, nor in isolation of the socioeconomic 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 which both boost socioeconomic development and minimise further environmental degradation. This requires a better understanding of how food systems operate in the region. It also requires recalling that food security involves

considerations of all aspects of the food system, not just food production and food availability; food security is diminished when any aspect of the food system is stressed.

6. Potential technical and policy approaches and constraints for enhancing Southern African food security in relation to GEC

A regionally-integrated and forward-looking food system strategy is needed that both 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. 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 however valuable in helping to identify where adaptive strategies may best be targeted. Some examples are given in Table 3.

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

Increasing food production

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). If sub-optimally managed, even a "low-tech" option such as changing crop can have significant negative consequences. For instance, a number of countries in Southern Africa are promoting roots and tubers as a drought adaptation strategy (IITA, 2004; Mharapara et al., 2005). However, as many smallholder farmers consider that these crops do not require additional nutrients, this form of adaptation is likely to aggravate the decline in soil fertility.

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 smallholder farmers and many farmers recycle hybrid seed and produce maize without application of fertilizer thereby missing much of the benefit of the new technologies (Mharapara, et al., 2005).

Another approach is to develop policies that support greater reliance on *veld* products as opposed to conventional agriculture. As noted above, *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, in press). This idea is developed further in Von Maltitz et al. (in press), 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. Such an approach will facilitate species migration to track suitable habitats in response to climate change which will be difficult to realise in protected areas without costly interventions such as the establishment of corridors.

Food production is clearly important, but food storage and distribution, and exchange also determine food availability.

Improving 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. When damage is not repaired, the resulting impacts on food distribution become substantial (particularly in times of stress, when it is most urgently needed) and lasting. As Stilwell (2000) notes: “The relative abundance of land and low population densities in Sub-Saharan Africa associated with highly scattered settlements result in extremely high transportation and communications costs, which make isolation and underdevelopment of rural communities inevitable. The problem is aggravated by low maintenance standards due to limited budgets and the fact that budgets are spent on emergency repairs rather than periodic maintenance”. 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.

Improving 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 among the SADC Member States. The region is large and diverse enough to be a stand-alone economic zone and therefore regionalisation provides a possible key to increasing resilience in the region’s food systems and therefore food security.

Improving food access and utilisation

A range of technical and policy approaches therefore have been identified to adapt those parts of the food systems that contribute to the food availably component of food security at region-level, *vis.* production, distribution and exchange. Some are aimed at household and plot levels, others at regional considerations. 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. The socioeconomic and environmental effectiveness and viability of these adaptation options needs to be established and especially when they are implemented in combination (as is likely to be necessary). 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, and issues relating to food safety. Most however are more primarily related to either economic issues (e.g. affordability) or social and political issues concerning the social function of food or food allocation. Campaigns such as that to increase the production of more drought-tolerant roots and tubers is being implemented without a thorough appreciation of food habits of the target communities; maize has become the dominant source of food in Southern Africa to the extent that alternative sources of nutrition such as cassava and sweet potatoes are treated as snacks. Changing public attitudes to food preferences via media campaigns would be required (e.g. accepting the more drought-tolerant roots or small grains over white maize) as part of an overall adaptation strategy.

8. The need for a regional policy perspective and associated research challenges

The growing concern that GEC will further complicate achieving food security in Southern Africa has been noted in a number of consultative meetings involving regional researchers, policy makers and donors in the region (GECAFS, 2006). However, as outlined above, the interactions among GEC and food systems are complex and need to be better analyzed to assess the implications for food security in Southern Africa. 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 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. As noted above, many national, regional and international programmes are targeting this important – and immediately obvious – research agenda. These efforts need to be complemented by approaches which consider the larger set of interactions between GEC and the food system *as a whole*. These will provide information to help decision makers and resource managers develop policy and technical adaptation options which improve food security whilst minimising further environmental degradation at a range of scales.

Importance of a regional policy perspective

Technical, agronomic adaptation strategies (e.g. development of heat tolerant crop varieties, water-use efficiency strategies) are designed for application at the local level (albeit with widespread adoption envisaged) and can be very effective given suitable local and regional policy enabling environments. Many of the more economic- and policy-related strategies for adapting the region's food systems may however be most effective if approached from the perspective of the Southern African region as a whole. 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, eg in terms of improved intra-regional trade, food storage and transport facilities. Third, some environmental management issues only manifest at this spatial scale (eg 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; local-scale approaches are often constrained by the particular local conditions. 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 (e.g. ICLEI, 2006).

The possibilities of establishing strategic grain storage and reserves, and the development and maintenance of infrastructure to reduce transport costs and food delivery time has been noted above. A more radical option proposed by Arntzen et al. (2004) is the possibility of within-region specialisation in food production and food trade. Southern Africa can be sub-divided into a high(er) agricultural production potential area in the north and east and marginal production areas in south central and west. Soils and water resources contribute to the differences in potential, and GEC is expected to further polarise the differences. The south central is expected to be negatively affected while the north and east may benefit from GEC. As the GEC impacts on food production appear different and the growing gap in production potential will necessitate stronger trade and transport links.

Whatever option (or combinations of options) are promoted, regional efforts require political commitment from regional countries to design and implement the efforts.

Research needs in the context of 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 over recent years has addressed the agronomic aspects of climate change, and particularly crop yield. This has provided an excellent foundation for assessments of how climate change may affect crop productivity, but the connectivity between these results and the broader issues of food security at large are relatively poorly explored; too often discussions of food security policy appear to be based on a relatively-narrow agronomic perspective. Further, while many natural science issues are already being addressed at the regional scale (e.g. Tyson et al., 2002), social science theories, methods and data are often better developed at the micro- and macro-scales (Rayner and Malone, 1998). Despite this disparity, socioeconomic and biogeophysical factors need to be integrated within an interdisciplinary research approach that recognises the interconnectivity between policy set? at different spatial scales. Given the varied policy interests of regional and local stakeholders,

and recognising the complex spatial and temporal dynamics in the region, research needs to recognise that some adaptation options (particularly in the policy domain) may be found by considering the region as a whole while others are of a more local nature due to, for instance, regional customs and practice, resources and attitudes. Some research issues are methodological in nature, such as how the understanding of food system vulnerability changes as different scales of analysis are employed. Others relate more to the nature of adaptation, such as how adaptation strategies at regional level influence sub-regional food security and local peoples' capacity to adapt; or how the outcomes for regional food security would differ given sets of multi-scale policy responses under different scenarios.

Such studies need to build on the wealth of disciplinary studies which have characterised most GEC and food-related research to date. These include, for example, studies on: GEC impacts on agro-ecosystem productivity (eg Gregory et al., 1999; Fuhrer, 2003); GEC impacts on regional production (eg Fischer et al., 2002; Jones and Thornton, 2003); societal perceptions of GEC (eg Thompson and Rayner, 1998); vulnerability of agricultural systems (eg O'Brien et al., 2004); seasonal forecasting (eg Colman et al., 2000); and the spatial scale of climate information in analyses of climate change impacts (eg Mearns et al., 2001). New research needs to build on and integrate such studies. It also 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).

Apart from the disparity between natural and social science perspectives, the research community faces several major scientific challenges in dealing with the interactions between GEC and food security. Four issues are of particular interest because they set the context for many researchable questions and will provide policy-relevant research insights. First is the need to better understand what constitutes vulnerability to GEC in relation to food. This is key to helping to determine where, when and which sections of society are most at risk, and is especially necessary given problems of predicting global food production (Döös, 2002). Second is the need to construct scenarios of future conditions that encapsulate the socioeconomic and biogeophysical factors that determine food security. A recent review of major scenario exercises has shown them to be deficient in many factors important for food security considerations (Zurek, 2006). Third is the need to assess options for reducing the vulnerability of food systems to GEC. Fourth is the need to understand how best to report and communicate research results and so help devise improved policies to adapt food systems to GEC.

9. Conclusions

Better governance in relation to GEC needs to be built on the three-way links between science, policy and practice. This is particularly so for food security issues in Southern Africa, where GEC is anticipated to have significant impacts. Policy, and particularly that 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 both in the region and internationally 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 in Southern Africa must provide practical assistance to evaluate options for reducing vulnerability of Southern African 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 is a valuable awareness-raising exercise in its own right, but it also 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). Participatory research as described will provide information to help decision makers and resource managers develop improved policies and technical adaptation options which improve food security whilst minimising further environmental degradation. It will also raise awareness of GEC issues in the policy community, and help the research community better understand the information needs, and constraints, of policy formulation. 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.

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1246 **Table 1**: Key characteristics of subsistence and commercial producers.
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	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)

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

Coastal Country	Name of Corridor	Sea Port	Neighbouring Destinations	Distance to Destination (approx. Km)
Tanzania	Northern Corridor	Dar Es Salaam Port, Tanzania	Mbeya, Tanzania/Malawi	850 km
			Lusaka, Zambia	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
			Blantyre, Malawi	1250 km
		Maputo Port, Mozambique	Harare, Zimbabwe	1270 km
South Africa	Southern Corridor	Durban Port	Harare, Zimbabwe	2070 km
		East London	Harare, Zimbabwe	2370 km
		Port Elizabeth	Harare, Zimbabwe	2460 km
		Cape Town		2890 km
Namibia	Western I Corridor	Walvis Bay, Namibia	Livingston, Zambia	1700 km
Angola	Western II Corridor	Luanda Port	Malanje, Angola	350 km
		Namibe Port	Menogue, Angola	650 km
		Lobito Bay Port	Kuito, Angola	584 km

1253 **Table 3**: Impacts of example stresses on different aspects of Southern African food systems.
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	Availability	Access	Utilisation
Climate variability	✓		
Water stress	✓		✓
Transport Infrastructure	✓	✓	
HIV/AIDS	✓	✓	✓
Monetary policies		✓	
Food Retailing Policies/Trends		✓	
Urbanisation/Migration		✓	
Information			✓
Unemployment		✓	✓
New Technology	✓		✓

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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. (From Scholes and Biggs, 2004.)