GLOBAL ENVIRONMENTAL CHANGE AND FOOD PROVISION IN SOUTHERN AFRICA:

Explorations for a possible GECAFS research project in southern Africa

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List of Acronyms

AIACC	Assessment of Impacts of and Adaptations to Climate Change in Multiple Regions and Sectors
APIS	Agricultural Potential and Trade Information System
CAADP	Comprehensive African Agricultural Development Programme
CDM	Clean Development Mechanism
CER	Certified Emission Reductions
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Centre
DFID	Department for International Development
ENSO	El Nino-Southern Oscillation
EU	European Union
FAO	Food and Agriculture Organisation
FSSF	Food Security Strategy Framework
FSTAU	Food Security Technical and Administrative Unit
GCM	Global Change Model
GHG	Green house gasses
GEC	Global Environmental Change
GECAFS	Global Environmental Change and Food Systems
GEF	Global Environmental Facility
GMO	Genetically manipulated organism
HDI	Human Development Index
IFPRI	International Food Policy Research Institute
IGBP	International Geosphere-Biosphere Programme
IHDP	International Human Dimensions Programme
ITC	Inter-Tropical Convergence Zone
NEPAD	New Economic Programme for African Development
UNEP	United Nations Environmental Programme
USAID RCSA	USAID Regional Centre for Southern Africa
RISDP	Regional Indicative Strategic Development Plan
SADC	Southern African Development Community
SACU	Southern African Customs Union
START	System for Analysis, Research and Training
TWAS	Third World Academy of Sciences
UNCED	UN Conference on Environment and Development
UNFCCC	United Nations Framework Convention on Climate Change
WCRP	World Climate Research Programme
WFP	World Food Programme

1 INTRODUCTION

This report is the result of a brief study that has been carried out in the period December 2003 to February 2004 by Jaap Arntzen, Pauline Dube and Martin Muchero for the Programme Office of the Global Environmental Change and Food Systems Programme, UK.

1.1 GECAFS in the context of Global Environmental Change

Many of the 200 million people living in Southern Africa rely on the immediate environment for food security, either from agricultural activities and fisheries or from veld products. A combination of man-made and natural factors is rapidly eroding the capacity of the southern African ecosystems to support food production and provide food security. As a result, food production has stagnated or even declined, and food insecurity has increased.

Key factors affecting food provision include political instability, poor governance, droughts, population growth, urbanisation, poverty, low economic growth, inadequate agricultural policies, trade terms and regimes, resource degradation and recently HIV/AIDS. Different factors determine the state of food provision in different countries. For example, Angola and the Democratic Republic of Congo have favourable climatic and physical conditions, but they perform far below their capacity in food provision due to political instability and poor governance. In contrast, (semi) arid countries such as Botswana and Namibia, produce insufficient food, but successfully achieve food security through food imports due to economic growth and good governance. South Africa is currently the dominant exporter of many food products; other countries export specific products only (e.g. beef, fish). Southern Africa is a major and regular recipient of international food aid to improve food provision. In general, national and regional decision-makers are faced with major short-term challenges in food production and provision which constrains ability to consider long term issues in food systems.

The medium and long-term impacts of global environmental change (GEC) need to be superimposed on the immediate pitfalls in food production and provision in the region, and this task poses a serious challenge to policy makers and researchers alike. One of these challenges is the need to formulate policies that are built upon a solid understanding of the links between GEC and food provision. The Global Environmental Change and Food Systems (GECAFS) initiative was designed to address this challenge and specifically focusing on:

1. How might the projected climate change stresses *further* affect the food systems of Southern Africa; *who* and *which place* will be most vulnerable to these changes?
2. What are the other key determinants of short and long-term food provision that needs to be addressed simultaneously with GEC?
3. What measures can be put in place to minimise impacts of GEC and or take advantage of positive trends that may arise from these changes?
4. What is likely to be the short and long-term feedback from measures adopted specifically to avert negative impacts or take advantage of changes in climate patterns?

Attention for GEC in Southern Africa increased significantly since the establishment of the United Nations Framework Convention on Climate Change (UNFCCC) at the UN Conference on Environment and Development (UNCED) in 1992. All Southern Africa countries are signatory of the UNFCCC and are expected, among others, to:

- Develop national programmes for reducing emissions of green house gases and develop strategies to combat the impacts of global warming and climate change;
- Develop and elaborate appropriate and integrated plans of adaptation to the impacts of global warming and climate change; and
- Take account of global warming and climate change in all social, economic and environmental policies and actions.

Since then, several international science programmes were constituted to address climate change. Among the most influential global research programmes are the World Climate Research Programme (WCRP), the International Geosphere-Biosphere Programme (IGBP) and the International Human Dimensions Programme (IHDP).

Despite these initiatives, to date, GEC-issues are not a priority in national development plans and are rarely reflected in development policies. While this is in part due to lack of resources and a pre-occupation with short-term priorities and calamities, it is also partly due to limited understanding of the significance of GEC, particularly the effect of climate change on sustainable development and key livelihood issues such as food provision. The available information on climate change in Southern Africa remains general in nature, and is not easily accessible to policy makers. This particularly applies to food, which was treated in a fragmented manner by different GEC initiatives prior to the establishment of GECAFS.

The GECAFS-initiative is the first GEC-initiative to consider the interactive effect of land use changes, climate variability and socio-economic factors on food systems with the aim of assessing the degree of vulnerability to future climate change and addressing adaptation strategies [www.gecafs.org). The goal of GECAFS is to:

> *To determine strategies to cope with the impacts of global environmental change on food systems and to assess the environmental and socioeconomic consequences of adaptive responses aimed at improving food security.*

The initial priority in GECAFS is to establish scientific information needs for designing informed policies on food systems in the light of GEC. GECAFS has launched regional projects in South Asia and the Caribbean, and is now considering the establishment of a regional project in southern Africa (figure 1).

This report reflects the findings of the 'scoping' exercise done for a southern African GECAFS project at the request of the GECAFS programme office. The work programme for the consultancy comprised the following tasks:

1. Identify a range of potential stakeholders who could:
    - Help to identify a GECAFS project in terms of policy information needs; and
    - Assist with identifying existing relevant information.

2. Solicit from potential stakeholders the nature of information needs related to Southern African food systems within the GECAFS context, and from regional scientists on-going, relevant research.
3. Draft a background paper outlining key research issues within the GECAFS framework for discussion at a follow-up research-planning workshop. The niche of GECAFS, the value added by GECAFS and the new interdisciplinary GECAFS science areas need to be highlighted.

The authors have used the following methods to implement the work plan: 1. Interviews with policy and research stakeholders; 2. Literature review of research and policy documents; 3. Review of agricultural statistics; 4 Review of information on GEC in Southern Africa. Given the limited resources and time, it was impossible to be comprehensive in terms of coverage of SADC countries and stakeholders, and literature. The team's activities have focused on the southern part of SADC (Botswana, South Africa and Zimbabwe), and on national and international stakeholders and literature accessible in those countries. The team has further relied on its network of contacts to bring in additional relevant experiences (e.g. food security programme in Namibia and climate change information from the UNEP/GEF/START/TWAS project on Assessment of Impacts of and Adaptations to Climate Change in Multiple Regions and Sectors (AIACC). The team has successfully used this information to scope food provision and GEC issues that are relevant to the whole region in line with the terms of references spelt out above.

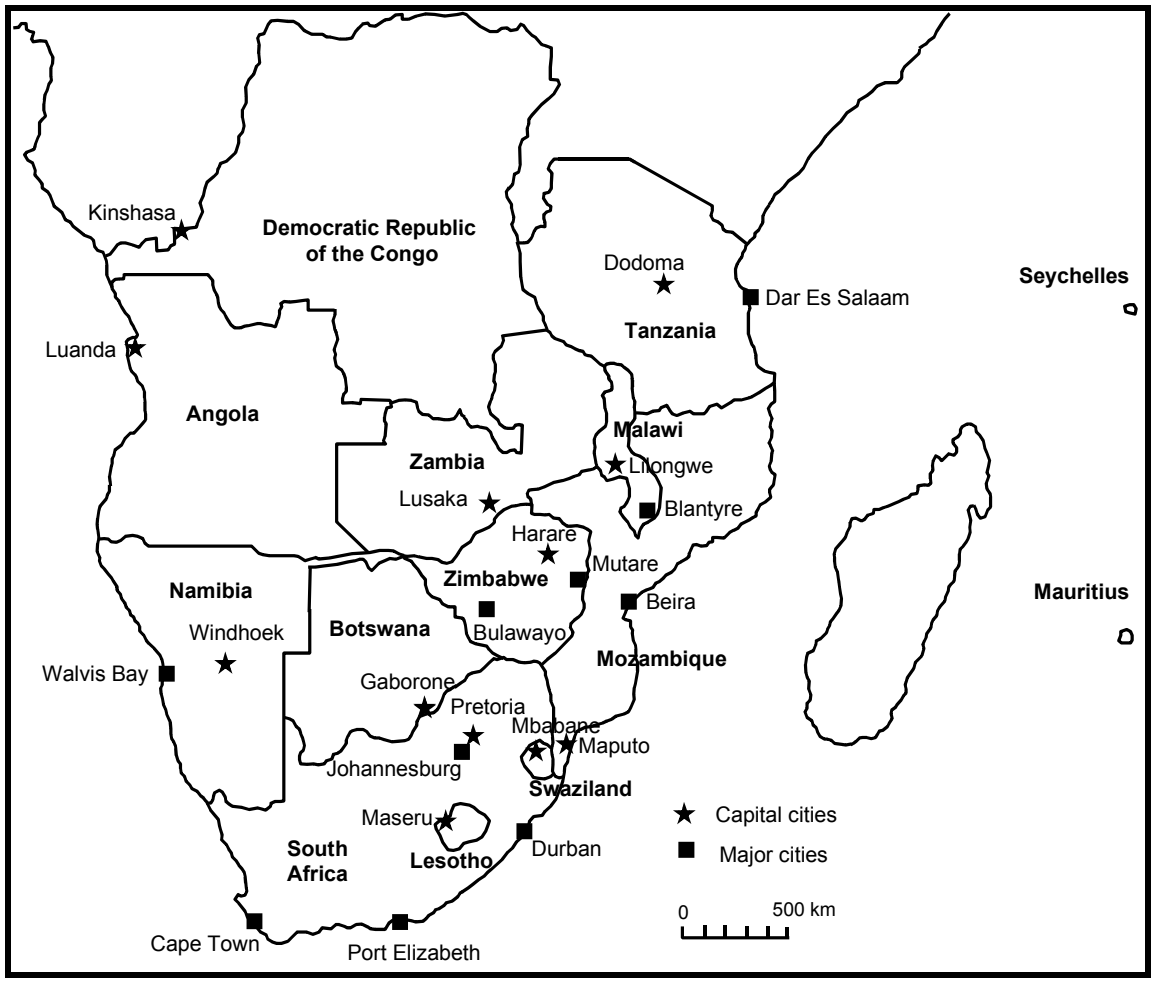
The report has the following structure:

Section 1 introduces the report (1.1), classifies and characterises the main food provision systems in southern Africa (1.2) and identifies the main trends in food production and distribution (1.3).
Section 2 discusses the main socio-economic and physical features of southern Africa (2.1), the GEC that are or occurring or have been predicted for southern Africa (2.2), and the environmental and development goals that have been formulated for the region (2.3). This section provides the context within which GEC as an *additional* determinant of food provision must be understood.
Section 3 reviews major regional policy and research initiatives to improve food provision. Special attention is given to SADC (3.1), NEPAD (3.2), CGIAR (3.3) and several donor initiatives (USAID RCSA). These include the major potential stakeholders, and projects where GECAFS-SA could add value.
Sections 4 to 6 review the main policy and research topics that have emerged from the literature and interviews for the three GECAFS themes:

- Impacts of GEC on food provision and vulnerability (section 4);
- Adaptations to the GEC impacts on food provision and vulnerability (section 5); and
- Likely environmental and economic impacts of the adaptations (section 6).

These sections provide the broad contours of a GECAFS project in southern Africa and aim to indicate the niche and extra value of GECAFS project.

F*igure 1*: Map of southern African region (SADC)



1.2 Review and characterisation of southern African food systems

1.2.1 Food provision

Human food resources are 'substance(s) taken into the human body to maintain life and growth' (Oxford Dictionary) and cover a diverse range of products:

- Cereals and other conventionally cultivated crops;
- Vegetables, fruits and edible oils;
- Meat, milk and dairy products;
- Fishery products; and
- Other (non-conventional) products collected from the natural environment or cultivated.

Food provision is therefore about *ensuring that people take in sufficient variety of substances to maintain life and growth*.

Each food resource (and species) has its unique 'production belt', which is based on physiological and climatic conditions, and which leads to comparative advantages and disadvantages in the production of specific food resources (species).

At the regional level, the number of 'food surplus' countries has decreased, increasing the region's overall dependency on global markets and food aid. At the national level, few countries produce enough food to meet their own needs, making the rest dependent on their capacity to purchase imported food (e.g. Namibia and Botswana) or on food aid (e.g. Lesotho, Malawi and Zimbabwe). At the local level, many households are poor, cannot cover their own food requirements, and rely on food aid. Food distribution networks are often inadequate to ensure availability of sufficient food at the local level.

While GECAFS adopts a regional approach, it is important that it recognises three spatial levels (local or producer/ consumer level, national and international) and their interactions. Food provision deals with the entire food chain from production to consumption. Adequate food provision centres on the following interlinked aspects in the food chain, food *production*, *availability* and *economic accessibility* of food.

Food production depends strongly on physiological conditions that determine the suitability of areas for food production (comparative advantages), and the costs of production. Yields and areas are co-determined by production management and policy incentives. Governments face an important policy dilemma in pursuing food self-sufficiency or food security. Due to the high economic costs of food self sufficiency, dry countries such as Botswana and Namibia have shifted towards food security. Producers face a wide variety of constraints, including over dependence on a high-risk crop such as maize, declining soil fertility, obtaining inputs such as seeds and fertiliser, water, lack of credit and access to new technologies, weak market linkages, including information (USAID-RCSA, 2003).

Food availability is determined by food production and distribution networks/ imports. It is obvious that food production in principle increases food availability. However, distribution networks (e.g. roads, communication, modes of transport and information systems) and

the financial situation of governments and consumers determine the ability to get imports/movements inside the deficit country and/or area. Major developments have occurred, particularly in the regional distribution networks, but especially sub-national infrastructure requires further development or maintenance to get food quickly to shortfall areas and groups. The storage and handling capacity is important for physical food reserves, but it is expensive and local capacities may have decreased due to stagnating yields.

Economic accessibility of food is determined by the price of food and by the purchasing power of consumers and governments. The price of food resources firstly determines the amount consumed. Obviously, the more expensive food is, the less the consumer can purchase. Low food prices are attractive to consumers, but are known to discourage agricultural production and productivity, as farmers fail to meet the costs of inputs and make a profit. Prices are determined by the efficiency of production (based on comparative advantages and good production techniques) and market conditions or government regulations. Secondly, the purchasing power of households and governments and competing demands determine their capacity to purchase food. The rising health costs are an example of competing demands for scarce funds at the household, national and regional level. Poorer governments and consumer groups do not have access to sufficient food, rely on food aid or face malnutrition, if no proper remedial action is taken. Both (aid and malnutrition) are widespread in southern Africa.

Food provision is closely related to the concept of *food security* that has superseded the policy objective of food self-sufficiency in most semi-arid southern African countries (e.g. Botswana and Namibia). Dry countries have realised that food self-sufficiency is extremely difficult to attain, and the costs are much higher than the costs of food imports). Food security can be described as the '*physical, social and economic access to sufficient, safe and nutritious food, which meets people's dietary requirements and food preferences for an active and healthy life* (Namibian Food Security and Nutrition Secretariat, 2001). The question arises whether *needs or preferences* should be targeted for food security. If consumers prefer maize or rice, but local environmental conditions favour sorghum and millet, which strategies for food provision/ security should be adopted: 1. Encourage farmers to grow sorghum and influence consumer preferences in favour of the 'local produce'; and/or 2. Encourage non-farm development to allow local consumers to purchase the preferred food themselves.

1.2.2 Food provision systems

As will be clear from the above, food provision systems rely on production systems, distribution and storage systems and systems governing economic access to food. Within this the adequacy and reliability of food provision depends on the performance of each sub-system and the interactions between sub-systems. For example, a lower than anticipated harvest could be compensated by rapid increase in food imports, but this requires a good marketing and distribution network.

Food production systems
Southern Africa hosts a wide variety of food production systems, determined by the:

- Type of food (conventional and non-conventional food sources; fish, cereals, meat);

- Method of production (from the wild; 'in situ controlled' with low or high external inputs); and
- Production strategy (subsistence or commercial and low/ high input strategies).

Generally, food production 'from the wild' is decreasing, except in extremely dry areas or during drought periods. Production of conventional food sources constitutes the (growing) majority of food production. Most of these are exotics, and may not be fully compatible with local environmental conditions (e.g. maize). There is growing interest in game ranching in the region, but on the plant side, there has been little progress with the production of non-conventional and environmentally adapted crops that can either be sold to purchase food or directly provide food.

There is no widely accepted classification of food systems in southern Africa. Table 1 is an attempt to classify food production systems based on their orientation, commercial or subsistence. Commercial production is production for the market, while subsistence production is meant for own consumption or bartering with neighbours and relatives. The main types of food production are crops, animals, forestry, fisheries and mixed farming systems.

Table 1: Food production systems in southern Africa by strategy

Type of agriculture	**Subsistence agriculture**	**Commercial agriculture**
1.Extensive natural harvesting	Hunting-gathering, including fuel wood	Very limited
2. Cultivation of crops, vegetables and fruits	Dry land crop production; Mostly a mixture of conventional crops (cereals, beans, melons).	Specialisation for cereal production; horticulture and fruits. Irrigation and large scale production
3. Rearing animals (domesticated and game)	Livestock farming	Mostly ranching (beef, dairy, breeding); move towards game farming in drier areas of Botswana, Namibia and South Africa
4. Mixed arable/ animal farming	Spatially separate; done by one household	Yes
5. Forestry system	Very limited	Forest estates
6. Fisheries	Yes	Yes; inland fish farms mostly in Lake Kariba

Generally, subsistence food production no longer appeals to the youth, who prefer to secure food provision by increasing their non-farm income to purchase food. Southern African food production systems can be described as 'in transition' in two ways. Firstly, there is a move away from subsistence production where possible[1]. Secondly, a transition process is taking place within the commercial sector to a future with less subsidies and political weight for the agricultural sector, less abundant and suitable land, and substantial participation of indigenous, often previously disadvantaged population.

Both transition processes put considerable pressure on food production.

Food availability system
Key sub-components of the food availability are:

- Transport networks (road, railway, port)

[1] A movement back to subsistence food production occurs during economic hardship when poverty and unemployment increase (e.g. Zimbabwe).

- Distribution networks (movement of production inputs and food);
- Storage networks, including storage at the farms, national depots and regional storage facilities).

Both governments and the private sector participate in distribution and storage networks. Transport networks have been mostly in the public domain.

Economic access system

Key sub-components of economic access system are:

- Income generation and economic growth;
- Income distribution and poverty reduction; and
- Food pricing systems.

Economic access is an important issue at the local and national level. Nationally, economic growth, governance and sound macroeconomic policies tend to improve national income and government revenues. Income distribution and poverty reduction systems as well as pricing systems (e.g. market or controlled food prices) influence economic access of local consumers. At the local level complex socio-economic factors such as gender relations, distance from main centres, culture and ethnicity influence literacy, access to information, income generating power and eventually economic access.

Where consumers or governments lack the resources to purchase, food aid is important to prevent food deficits and malnutrition. However, food aid creates uncertainties and dependency.

1.2.3 Producers' classification

In strategic terms, two categories of farmers are commonly distinguished. The first category of commercial farmers produce crops or livestock etc. to maximise their profits and sell the bulk of their products on the market; they run farms as business operations. Profit maximisation can be pursued through cost minimisation or through maximisation of revenues. Farmers choose the production level where their net marginal costs equal the net marginal benefits (= price). Unlike for many other economic sectors, this rule is difficult to apply ex ante in agriculture due to natural and human factors? For example, droughts and floods negatively affect production and production costs, and make it difficult to plan for the optimal situation. Human causes include government interventions and market imperfections that make it difficult to control production costs and particularly revenues.

Subsistence farmers, on the other hand, do not aim at profit maximisation but instead seek a satisfactory and secure livelihood. Their livelihood consists of in-kind and cash sources, and is derived both from agricultural and non-agricultural sources. A diversity of livelihood sources (agriculture and non-agriculture) reduces risks and increases livelihood security.

Key characteristics of each category are summarised in Table 2. 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. Historically, commercial farmers were advantaged, but advantages such as subsidies and cheap water and labour are being abolished. And in some countries such as Zimbabwe land re-distribution policies have resulted in a significant reduction of commercial farmers.

Table 2: Key characteristics of subsistence and commercial farmers.

	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 and fenced off 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
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, output system Modern practices aimed at profit maximisation
Human resources	Mostly indigenous skills	Mostly modern agricultural 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)

The above discussion shows that food provision should be analysed by putting agricultural development in the broader context of economic development. Food provision can be stimulated by growth in agricultural production and or by economic growth and higher incomes of government and household to purchase food.

1.3 Regional and sub-regional trends in food provision

While population growth has slowed down from above 3% in the 1970s and 1980s to an average of 2.7% per annum in the 1990s, the increase remains above the growth rate of food production of only 2% per year (Banzinger et al, 2001). While this net decline in per capita food production is partly met through imports and food aid, in many cases,

populace is simply eating less. Approximately 100 million people in sub-Saharan Africa are malnourished, 30 million of them children under the age of five years.

Table 3 depicts agricultural land use and potential in the SADC countries. Clearly, the total potential agricultural area is heavily underutilised, as only 20% of the suitable land is under cultivation. Moreover, the irrigation sector is small in most countries, except for South Africa and Zimbabwe.

Table 3: Land use and agricultural potential of the SADC countries in 1987 ('000 ha)

Country	Total Area	Land Area	Potential Agr. Area	Cultivated Area	Forestry & Others	Irrigation Area	Cultivated Agr. Area (%)	Cultivated area Irrigated (%)
Angola	124,670	124,670	31,500	3,500	93,500	10.0	11.1	0.3
Botswana	60,037	58,537	5,330	1,330	53,207	2.0	25.0	0.2
Lesotho	3,035	3,035	861	361	2,174	1.0	42.0	0.3
Malawi	11,848	9,408	3,273	2,273	6,148	18.0	69.0	1.0
Mozambique	80,159	78,409	40,409	3,080	38,000	70.0	7.6	2.3
Namibia	82,429	82,329	-	662	43,667	4.0	-	0.6
South Africa	122,320	122,320	29,057	13,174	4,369	1,130.0	45.3	8.6
Swaziland	1,736	1,720	364	161	1,364	62.0	44.2	3.5
Tanzania	91,509	88,604	45,030	5,030	43,574	146.0	11.2	2.9
Zambia	75,261	74,071	24,998	4,998	49,074	20.0	20.0	0.4
Zimbabwe	39,058	38,667	3,524	2,524	35,143	185.0	71.6	7.3
Total	**692,062**	**681,770**	**184,346**	**37,093**	**370,220**	**1,648.0**	**20.1**	**4.4**

Source: Stilwell, 2000.

Table 4 shows the trend in per capita consumption of staple grains. The trend in per capita grain consumption is presented in Table 4. In most countries, per capita consumption has decreased, as a result of inadequate food production and inability to import/ purchase grains. Nine-tenths of maize produced in Sub-Saharan Africa goes directly for human consumption. (Banziger et al 2001).

Table 4: Per capita consumption of staples from 1985/86 to 1996/97 for the SADC countries (kg/capita)

Per capita Consumption	1985/6	1986/7	1987/8	1988/9	1989/90	1990/1	1991/2	1992/3	1993/4	1994/5	1995/6	1996/7
Angola	50.7	62.1	62	58.9	67.1	64.9	68.7	67.7	67	52.6	33.8	36.5
Botswana	151.8	135.9	130.6	136.7	180.5	183.8	175.8	174.4	200.1	197.7	186.2	191.8
Lesotho	146.8	126	126.8	173.8	178.1	199.3	202.8	209.3	207	187.4	210	181
Malawi	154.4	172.5	168.8	164.7	142.7	142.3	127	121.6	129.5	108.4	137.8	147.1
Mozambique	60.4	64.3	61	66.2	70.3	78.9	70.4	89.8	74	75	49.8	60.4
Namibia	94.1	91	113.8	118.7	111.5	105.2	107.9	120.5	114.7	119.5	119.6	114.1

South Africa	163.9	165	184.9	179.4	174.7	172	170.3	151.7	168.2	143.8	141.2	131.8
Swaziland	182.6	114.1	190	133.3	187.9	132.7	130.3	137	174.3	100	95.4	107.2
Tanzania	86	87.2	84.5	83.3	90.5	93.4	84.1	69.2	66.4	70.3	71.8	71
Zambia	147	140.6	146.4	157.4	167.6	167	147.7	140.6	147.5	141.8	115	124.4

Source: Stilwell, 2000.

Table 5 shows the importance of various crops in terms of local production, consumption and import. Maize is the most important grain in all respects (production, consumption and imports). Obviously, the impacts of GEC on maize are of critical importance to the region's food provision. Rice is a major staple, and mostly imported. The same applies to wheat, although there is some production in the region. More drought resistant grains such as sorghum and millet appear to be the least important at the regional level. Their production is confined to the semi-arid areas, and consumption is relatively low (with the exception of Botswana).

Table 5: Importance of main grains for production, consumption and imports

	Food Production (average production share for period 1990-2003)	**Food Consumption**	**Imports (product and share in total imports 92-2001)**
Largest grain	Maize (81.0%)	Maize	Maize 45.9%)
Second largest	Wheat (8.3%)	Rice	Wheat (34.0%)
Third largest	Sorghum/millet (7.4%)	Wheat	Rice (17.7%)
Fourth largest	Rice (3.4%)	Sorghum-millet	Sorghum (2.2%)
Fifth largest	No data		Millet (0.1%

Source: based on SADC-FANR data

1.3.1 Trend in regional food production

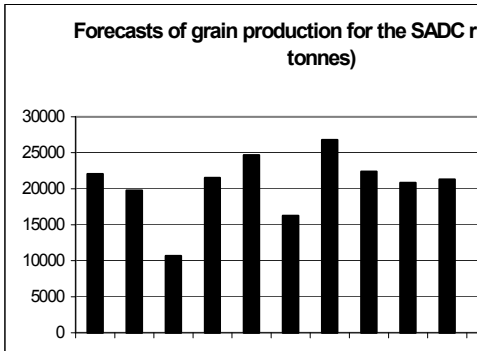
Grain production

Figure 2 summarises the trend in forecasted grain production[2] in the SADC region. In most years, the region should be self sufficient in grain production as production exceeds the 'normal consumption estimated in the range of 13 to 17 million tonnes (1992/93 estimate SADC). Production clearly decreases during droughts (e.g. 92/93), but overall production shows a cautiously upward trend. The average annual forecasted production has risen from 16.5 million tonnes in the period 1990-96 (including the 92/93 drought) to 22.5 million tonnes in the period 1997-2003. If the drought year of 1992/93 were excluded, the average for the period 90-96 would be 21.8 million tonnes. The coincidence of a poor season in all SADC countries resulted in severe shortages and the need for international assistance in 1992.

[2] No actual production figures were obtained from SADC.

Figure 2:

2003
713
619
0
11
83
32
2
0
0
30
94
75
12
0



Source: FANR-SADC.

A breakdown by type of grain shows that maize is the major crop (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. The share of maize is increasing slowly, mostly at the expensive of wheat production.

Koester (IFPRI 1993) compared production patterns in Malawi, Tanzania, Zambia and Zimbabwe with the suitability of growing crops (Table 6).

Table 6: Suitability shares and production shares for the main food staples (1986-88 as percentages)

	Malawi		Tanzania		Zambia		Zimbabwe	
Crop	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**
Maize	100	83	76	27	97	81	59	81
Cassava	96	10	50	62	60	16	24	4
Phaseolus beans	99	5	75	3	96	0	59	2
Sorghum	100	1	75	5	86	2	59	5
Millet	53	1	74	3	94	2	53	7

share of these five staples.

Source: IFPRI 1993

His findings show a huge difference in the grain growing potential among the four countries. Grain production does not only reflect local environmental conditions but also revealed preferences of policymakers in each country (e.g. maize in Zimbabwe).

Buckland (1993) argues that deliberate government strategies in the provision of services such as marketing facilities, agricultural extension services, input programmes and similar strategies have, in the past, stimulated maize production. A good example

of this relates to maize production in Zimbabwe before and after its Independence in 1980.

Prior to 1980, the bulk of marketed maize emanated from the large-scale commercial farming sector. This is less the case now, as expansion of the Grain Marketing Board's operations at independence into communal areas stimulated a marked increase in area sown to maize and in the volume of maize marketed by smallholder farmers. The spread of hybrids to small scale farming sectors and further increases in their use by the large-scale commercial farming sector are also reflected in the generally higher average yields in the latter part of the 1980s relative to the 10 years before. But the introduction of hybrids, while raising average yields, has also resulted in the amplitude of the fluctuations in yields getting larger. In good years, hybrids yield better than local varieties; in poor years, this tends to be reversed, raising questions about the suitability of current hybrids in risky, drought prone areas (Buckland 1993).

Livestock production patterns
Table 7 summarises the major livestock producing countries, as measured by the size of the national herd. Tanzania and South Africa are among the largest producers for most types of animals. Smaller countries like Botswana, Namibia and Lesotho are major secondary producers.

Table 7: The major livestock producing countries ranked by size of national herd (1 top country).

	Cattle	**Sheep**	**Goats**	**Pigs**	**Equines**	**Poultry**
1	Tanzania	South Africa	Tanzania	DRC	Malawi	South Africa
2	South Africa	Tanzania	DRC	South Africa	Namibia	Mozambique
3	Zimbabwe	Namibia	Zimbabwe	Angola	Lesotho	Tanzania
4	Angola	DRC	Angola	Tanzania	Zimbabwe	Zambia
5	Botswana	Lesotho	Botswana	Malawi	South Africa	Botswana

Source: SADC-FANR.

The cattle density (ha/ animal) is lowest in Swaziland (2.1 ha/cattle) followed by Tanzania and Lesotho (5.9 ha/cattle) and Zimbabwe (7.1 ha/cattle); SADC FANR data.

Storage facilities and grain reserves
Table 8 depicts the estimated grain storage facilities in the SADC countries in 1993, but excludes South Africa [not yet part of SADC at that time). The total grain storage was estimated at just under 8,5 million tonnes. Zimbabwe had the largest storage facilities at nearly 5 million tonnes capacity, excluding privately owned storage facilities. Most of these storage facilities were located on the lines of rail or main road trunks servicing commercial agriculture.

The National Strategic Grain Reserves were estimated at 1.4 million tonnes in 1993. The reserves have changed tremendously since then due to varying factors including lack of economic capacity to hold physical or even financial strategic stocks enough for more than just a couple of months. Comparing the national strategic reserves and storage capacity, Table 8 shows that the region has adequate storage capacity to store the reserves.

Table 8: Grain storage capacity and national strategic food reserves in SADC countries: 1993

Country	Grain Storage Capacity ('000 mt)	National Strategic Reserves ('000 mt)	Type of Strategic Reserve Commodities
Angola	114.70	N/a	-
Botswana	140.00	80.0	Sorghum & maize
Lesotho	120.60	9.0	White maize
Malawi	554.70	180.0	White maize
Mozambique	315.00	60.0	White or yellow maize
Namibia	20.00	N/a	-
Swaziland	61.10	15.0	White maize
Tanzania	808.00	150.0	White maize
Zambia	1335.70	10.0	White maize
Zimbabwe	4979.50	900.0	White maize
SADC (1993) Total	8449.30	1404.0	

Source: SADC Food Security Technical and Administrative Unit (FSTAU), 1993

Comparing the storage capacity with production and consumption figures, it becomes clear that apart from Zimbabwe, most SADC countries (this is before South Africa joined the SADC community) have smaller storage capacities than their estimated production and consumption figures. This situation has not changed much as there has been little serious additional capital expenditure in storage infrastructure in the region since 1993; even though the private sector has since entered this field of providing storage facilities following market liberalisation systems introduced in most countries in the early to mid 90s.

Transport networks

Sub-Saharan Africa is characterised by highly scattered settlements, resulting in high transportation and communications costs, and in isolation and underdevelopment of rural communities. The scattered pattern of rural settlements leads to a low density of road networks. (Stilwell, 2000). Road density ranges from 0.01 to 0.47 km of road length per km^2 of area. This is far below the 0.30 – 0.45 km of roads per square kilometre of land area in the Asian countries (Stilwell, 2000). Zimbabwe and South Africa are the only countries with similar densities.

Transport problems are compounded by inadequate maintenance due to limited budgets. This has resulted in high transport and communications costs in Sub-Saharan Africa.

Communication networks

Communications infrastructure is a pre-requisite for primary production for the market, for trade, commerce and industry (Stilwell, 2000). Access to communications infrastructure facilitates economic growth, as it reduces transaction costs. In relation to the SADC countries, and in terms of international norms, SADC's telecommunications infrastructure stock is poorer than its transport infrastructure stock.

According to Stillwell (2001) Mauritius is the only SADC country that meets the criteria of a "high-growth" country while South Africa meets the criteria only because of the very skewed distribution of its telephone network. Namibia falls between a middle-growth and a low-growth country. The rest of the SADC countries fall far below the world benchmark for low-growth countries.

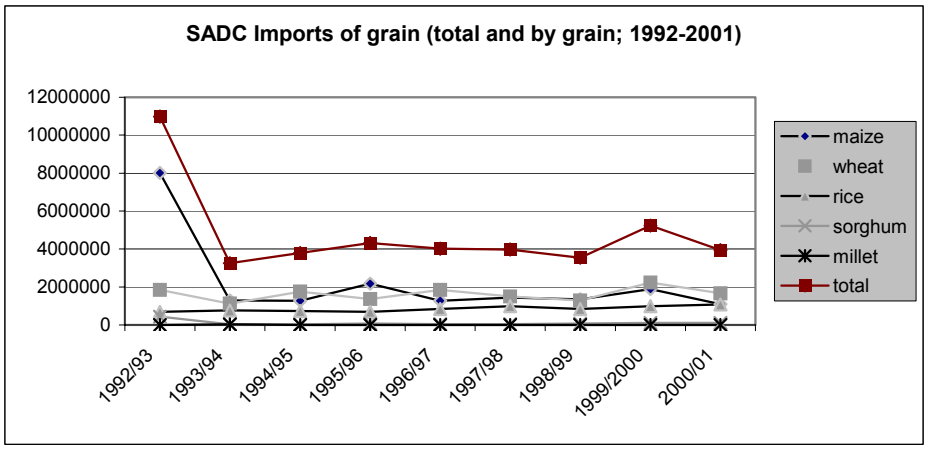
Improvement in road and communication networks should therefore also be a priority in the quest to improve food security and provision.

1.3.2 Food imports

Trends in food imports for (12) SADC are summarised in figure 3 (million US$). The costs of imports fluctuated between 30 to 55 million US$ in the period 1994-2003, but there is no upward or downward trend. During droughts the import bill may exceeds US$ 100 million (1992/93).

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).

Figure 3:



Source: FANR-SADC

1.3.3 Food aid

Eicher (2003) argues that Africa depended in the 1960s on agricultural trade, but by the seventies, the continent became aid dependent. Increased donor aid to agriculture in the 1970s was a response to the global economic turbulence (e.g. huge increases in oil and grain prices) and to optimism about boosting African agriculture through the successes of the Green Revolution of Asia.

In the ensuing 80s and 90s, there was a shift in development thinking and practice leading to donor driven economic liberalisation and reforms in the 80s and 90s. Poverty alleviation returned to the aid agenda in the 1990s and development thinking then focused on poverty alleviation, policy reform, decentralisation, sustainable livelihoods,

value-added exports and trade (Eicher, 2003). Eicher identifies a large donor challenge regarding poverty alleviation, which is significant to GECAFS:

> "How do external agencies – NGOs, foundations and donors – mobilize political support and resources for the poor (Lipton 1977). After all poverty is all about politics, power and access to knowledge, resources and markets."

During the 1990s, donor aid to agriculture decreased by around a third (Table 9).

Table 9: Net aid disbursements to southern African countries (US$ million)

	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Angola	418	473	355	335	388	307	268
Botswana	90	75	122	106	61	31	29
Congo Dem.Rep	196	166	158	125	132	184	251
Lesotho	114	104	92	61	31	37	54
Malawi	435	492	344	435	447	446	402
Mauritius	23	20	43	42	42	20	22
Mozambique	1064	888	948	1040	805	877	935
Namibia	192	188	166	181	179	153	109
South Africa	389	364	496	514	541	488	428
Swaziland	58	33	28	35	29	13	29
Tanzania	877	877	945	1000	990	1022	1233
Zambia	2034	610	610	349	624	795	374
Zimbabwe	492	371	336	262	245	178	159
Sub-Total	**6382**	**4661**	**4643**	**4485**	**4514**	**4551**	**4293**
Rest of Sub-Sahara	12038	11458	9602	9415	8209	8151	9237
Total	**18420**	**16119**	**14245**	**13900**	**12723**	**12702**	**13530**

Source: Adapted from Eicher, 2003, p.44

In summary, this section looked at the main food systems of southern Africa with consideration to food sources at local, national to regional scale. 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 provision chain. While the region has adequate grain storage facilities, distribution and communication networks remain poor. The following sections focus on the role of GEC on food systems of southern Africa, potential adaptation options and implications of such adaptations in the long run with the aim of setting up a pathway for designing a GECAFS activity that will address the needs of policy makers.

2 GEC in Southern Africa

This section provides the biophysical and socio-economic context of southern Africa that should shape the GECAFS project in southern Africa, and make it relevant to decision-makers.

2.1 The southern Africa region

2.1.1 Biophysical features

Climate: The climate of Southern Africa ranges from humid coastal zones to land-locked (semi-) arid lands, marked by high intra-seasonal and inter-annual variability. Rainfall levels and variability vary enormously within the region with the driest parts in the southern and southeastern parts of the region and wetter conditions with more reliable rainfall towards the north.

Droughts are common and floods occurred in 1999/2000. Such extreme events are often linked to the El Nino-Southern Oscillation (ENSO) phenomenon. Rainfall occurs in summer between October and April with exception to the southwest tip of the continent where winter rainfall is recorded. Higher rainfall is experienced in the northern parts due to the Inter-Tropical Convergence Zone (ITC) and the Atlantic Ocean Air masses. For example, mean annual rainfall of over 3000mm is found in parts of the Democratic Republic of Congo (DRC). In the southern parts most of the rain is from the maritime air masses of the Indian Ocean but their impact decrease westward and this combined with the effect of the cold Benguela current along the Namibia coast account for the semi-arid to arid conditions over much of the mid-southern part of the continent with mean annual rainfall as low as 50mm over parts of Namibia and 250 mm. on the western parts of Botswana (Ministry of Works, Transport and Communication, 2001).

No long-term rainfall-monitoring network exists as yet in southern Africa. Consequently, any changes in rainfall patterns have to be ascertained from long established individual rainfall stations in countries such as Botswana, Namibia, South Africa and Zimbabwe.

Soils and physiography: Much of Southern Africa is overlain by granite related rocks, which generally give rise to infertile soils. 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 aeolion Kalahari sands. Pockets of fertile soils are limited to drainage networks associated with the southern extension of the East Africa rift valley.

Drainage and water: Water resources are very limited in the region, particularly in the southern parts. Most of the available surface water in the region is shared among two countries or more, and its use is subject to the SADC Shared Water Resources Protocol. Five of the ten largest surface water bodies in sub-Saharan Africa occur in Southern Africa with basins extending from about 385 000 km^2 for Limpopo to 3720 000 km^2 for the Congo River (Sharma et al, 1996). Seven out of the twelve Southern African countries belong to multiple international river basins, typically involving four to nine river basins per country. Despite the noted network of rivers, water shortages constrain agriculture and other national development plans in the semi-arid parts of the region. Shared basins have important implications on water management, and agricultural water

sources due to growing water demand in other parts of the economy. Significant land use competition over the same water source also exists within the same country for instance, livestock versus wildlife in the Okavango Delta waters in Botswana.
Groundwater resources are mostly used for livestock production. Groundwater data are generally poor, but nonetheless resources are considered to be very limited in Botswana, Namibia and South Africa, and constrain livestock production. The amount of treated effluent is growing, and treated water offers important opportunities for irrigation, mostly close to urban areas.

Vegetation: Savanna vegetation dominates the region with mophane and fine-leaf acacia woodland being the most common species. On the drier Kalahari sands is shrubland with a relatively dense layer of less nutritious grass species and woodlands in depressions and along fossil valleys. In the wet northern areas broadleaf Miombo forest occurs. Wetland vegetation ecosystems found along the coast and inland wetlands are also significant.

Wildlife: The vegetation ecosystems of Southern Africa are home to a rich and diverse wildlife population, although numbers of many species have been declining (except the elephant). A significant proportion of land is under wildlife conservation areas, 17% of the total surface area in Botswana and 11% in Tanzania (Moyo et al., 1993). This supports the predominantly nature-based tourism industry, which is an important engine of economic growth.

Southern Africa has a large marine space, spanning from Tanzania on the Indian Ocean to Angola and this is a home to several migratory fish stock such as pilchard, mackerel, hake, shrimp, tuna and others. Inland fisheries are important for instance over Lake Malawi (Moyo et al., 1993) and now commercial fish farming on Lake Kariba.

Agriculture: Agriculture is the major form of land use in the region and involves both arable production and livestock rearing. In South Africa it accounts for 89% of the land surface (Schulze et al, 1995; Harsch, 2003). However, crop production remains a high-risk activity in the drier parts such as Namibia and Botswana where the agricultural sector only accounts for 3% of the national gross domestic product. Botswana and Namibia are highly dependent on food surpluses elsewhere in the region to meet their food security. But, despite this, agriculture has a significant role in meeting subsistence needs of rural communities in these aid zones of the region.

2.1.2 Socio-economic features

Southern Africa has plenty of development opportunities in terms of human resources, minerals, unique environmental assets and agricultural potential, but the potential remains underutilised due to a troubled political history and serious problems in attaining good governance, achieving rapid economic growth and regional integration and trade.

The main socio-economic features of southern Africa include low economic growth, illiteracy, poverty, lack of formal employment opportunities, poor governance, rapidly changing political and governance conditions, and marginalisation in the global economy. Clearly, the region's potential, including the agricultural one, is being under-utilised.

The region is dominated by South Africa that holds around a quarter of the population but three-quarters of the region's Gross Domestic Product. Southern Africa is also characterised by great socio-economic diversity, ranging from medium-income, highly successful economies to low-income, struggling economies.

High population growth has long been a problem for economic development and food provision in southern Africa. During the 1970s and 1980s, annual population growth exceeded 3% in many countries, but growth rates have fallen to an average of 2.7% for the SADC region in the 1990s. Recently, the incidence of the HIV/AIDS endemic and associated diseases such as Tuberculosis together with family planning measures have led to much lower growth rates, with a possibility of a declining population in some countries in future, and to a dramatic reduction in life expectancy at birth.

The region is rapidly urbanising, for instance, 58% of the population are in towns in South Africa, and in Botswana it is 49% (Kalabamu, 1994). Urbanisation brings about changes in consumption patterns and as a result brings new challenges in the food provision system. Despite the rapid urbanisation, a large section of the population remains based in rural areas. Many living in urban areas have substantive links to rural areas (up to 85% in Malawi), and as a result mostly depend on natural resources for daily needs. Economic stagnation and loss of formal sector employment have pushed people back into rural areas in countries such as Zimbabwe, as rural life is cheaper, and access to land offer some livelihood opportunities that are gone in urban areas.

The region's economic growth is relatively low and volatile. The average annual real growth was 1.87% in the period 1992-2003, with a range of –2.4% during the 1992 drought to a peak of 4.6% in 1996. Some countries have sustained a much higher record of rapid economic growth. Other countries such as Mozambique have accelerated growth in recent years, while Zimbabwe experiences negative growth.
Per capita income in the region varies from US102 in the DRC to US3589 in Mauritius. In terms of per capita income, the following classification can be made:

- A cluster of reasonable income countries: Namibia (US$ 1667 in 2001), Botswana, South Africa and Mauritius (US$ 3589 in 2001);
- Low income countries: from the DRC (US$ 102 in 2001) to Swaziland US$1109 in 2001);

UNDP uses the human development index as its chief development indicator. The HDI index is a composite index based on income, education and health achievements. Mauritius also performs best in terms of human development (rank 71; medium development). South Africa, Swaziland, Namibia, Botswana, Lesotho and Zimbabwe are also ranked as countries with medium human development. The other countries are labelled as low human development countries.

The unsatisfactory level of human development is also visible from several health and food indicators related to food provision. Table 10 shows the state of dietary in-take and child health and nutrition. Malnutrition and low child weights are common in the region, and dietary per capita in-take of less than 2000 calories per day are found in Angola, DRC, Mozambique, Namibia and Zambia.

Table 10: Some indicators of food security in SADC countries.

Country	P.c. energy supply	Year/ period	Infants with low birth weights		Rural child malnutrition	Year/ period
Angola	1,910	(1996 -1998)	19	(1990-1997)		
Botswana	2,210	(1996-1998)	11	(1990-1997)	34.00	(1990-1998)
DRC	1,750	(1996-1998)	15	(1990-1997)	52.00	(1990-1998)
Lesotho	2,230	(1996-1998)	11	(1990-1997)		
Malawi	2,170	(1996-1998)	20	(1990-1997)	44.00	1992
Mauritius	2,940	(1996-1998)	13	(1990-1997)		
Mozambique	1,780	(1996-1998)	20	(1990-1997)	38.90	1997
Namibia	1,860	(1996-1998)	16	(1990-1997)	32.40	1992
Seychelles	2,400	(1993-1995)	10	(1990-1997)		
South Africa	2,840	(1993-95)			27.00	(1990-1998)
Swaziland	2,490	(1996-1998)	10	(1990-1997)		
Tanzania	2,000	(1996-1998)	14	(1990-1997)	43.20	1996
Zambia	1,960	(1996-1998)	13	1990	45.80	1996
Zimbabwe	2,140	(1996-1998)	10	(1990-1997)	22.80	1994
	Cal.day		**% of births**		**% of stunted under fives**	

Source: World Bank, 2001.

Low economic and human development makes it difficult for most southern African countries to develop and maintain the necessary infrastructure.. It also forms a constraint for agricultural research, technology development and transfers and support to farmers. Many countries have a heavy foreign debt burden, and depend on foreign support and aid and the associated conditions for economic and political reforms.

Poverty is still widespread and unacceptably high, and ranges between 40 to 75% in most countries. The average human poverty index for the SADC region is 31.5 (1998) with the highest poverty recorded in Angola (54.7) and the lowest in Mauritius 11.5; (SADC annual report 2001-02). While some countries are gradually reducing poverty (e.g. Botswana), in other countries poverty has increased dramatically. Limited job opportunities and poverty continue to put pressure on subsistence agriculture and natural resources . Nearly all countries have large traditional subsistence small-scale food production systems, dominated by female-headed household.

Over 80% of the region's population relies on fossil fuel for energy, coal-fired power stations for electricity and biomass for domestic use. Combined with other activities this has resulted in deforestation and development of land degradation in extreme cases.

Access to clean water, energy, and health services and communication infrastructure is limited and this compromises the general well being of the society. The 'reasonable' income countries tend to have better water, communication, energy and sanitation conditions. As noted above less than a quarter of the roads are paved in the region, leading to high transport costs and hampering intraregional trade.

Low investment in human development in the region constrain governance and overall economic development and this will make it difficulty to attain some of the goals of the New Partnership for Africa (NEPAD) and to effectively implement GEC adaptation strategies in future. Political instability has constrained developments in for example

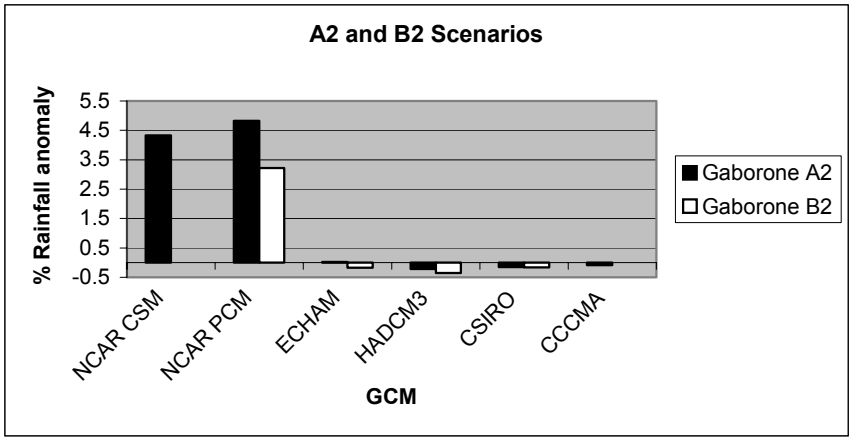
Angola and the DRC. The recent land distribution in Zimbabwe has negatively affected food security of the country and the region and this increases vulnerability to GEC.

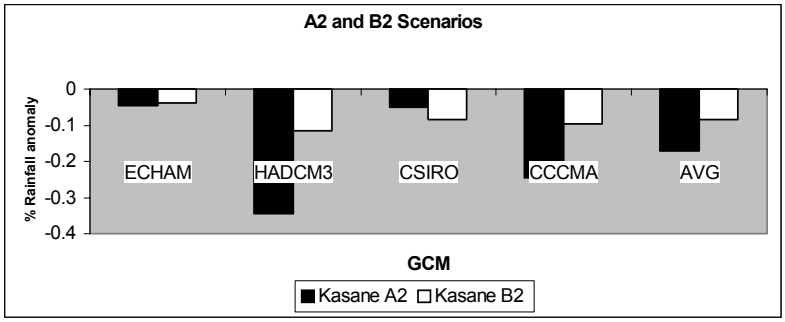
2.2 Global Environmental Changes for Southern Africa

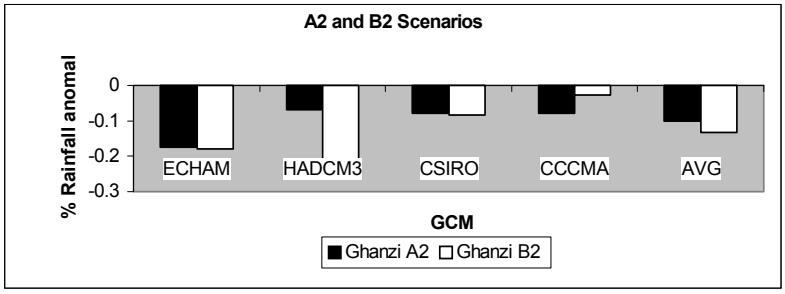
Studies on climate change have shown from station records that the world is 0.6^0 C warmer than 150 years ago. A trend of increasing temperature has been confirmed in different parts of Southern Africa. IPCC (2001) assessments showed, using different global climate scenarios, that temperatures over Southern Africa will rise by a range of about 2 to 5^0 C in 2050, affecting most the central land mass of the region occupied by Botswana, parts of Zimbabwe and South Africa and Namibia. At a global scale, a warmer climate will result in higher rainfall. However, although there are variations between results of different climate change scenarios, majority of climate models show that the opposite is likely to be experienced in sub-tropics, for example most of the central to western parts of southern Africa are likely to experience drier conditions. Results from six global climate models (GCM) over Botswana applied for two different scenarios, A2 and B2 confirm that aridity is most likely to occur although there will be temporal and spatial variation on the magnitude of change (figure 5).

Results of climate scenarios also signal a possibility for a shift in precipitation patterns, which may affect the length of the growing season (Ministry of Natural Resources, 2000). A reduction in the growing season rainfall of up to 15% in some parts of southern Africa has been indicated (Hulme et al., 2001). Also indicated is a general increase in climate variability and extreme events such as the 1983 to 1987 and 1991/1992 drought and the 1999/2000 floods.

Figure 5:







Percent annual rainfall anomaly by 2099 based on observed station data and rainfall simulation from six Global Climate Models: NCAR-CSM, NCAR-PCM, ECHAM, HADCM3, CSIRO and CCCMA (see Carter et al, 2000 for more information on GCMs). An example for all the six GCMs is shown for Gaborone. For Kasane on the wet northern tip of Botswana and Ghanzi, the western arid part of Botswana only results of the four GCMs that confirm dry conditions are shown as well as the average (AVG). A2 and B2 represent scenario families that describe future demographic, social, economic and technological developments that will have regional and global implications on green house gases. A2 represents a very heterogeneous world, with high population growth, regionally oriented economic development and fragmented and slower per capita economic growth and technological change. While B2 represents a world, which emphasises local solutions to economic, social and environmental sustainability, moderate population growth, intermediate economic development and less rapid diverse technological change (IPCC, 2000). Data was acquired through the UNEP/GEF/ START/TWAS project from the Climate Systems Analysis Group, University of Cape Town.

Percent annual rainfall anomaly by 2099 based on observed station data and rainfall simulation from six Global Climate Models: NCAR-CSM, NCAR-PCM, ECHAM, HADCM3, CSIRO and CCCMA. An example for all the six GCMs is shown for Gaborone. For Kasane on the wet northern tip of Botswana and Ghanzi, the western arid part of Botswana results of the four GCMs that confirm dry conditions are shown as well as the average (AVG). Data was acquired through the UNEP/GEF/START/TWAS project from the Climate Systems Analysis Group, University of Cape Town.

Research in the past decades has shown that changes in climate patterns are linked to an increase in greenhouse gases due to anthropogenic activities. However Africa's absolute contribution to all green house gas (GHG) emissions is the lowest, according to Hulme et al. (1995) about 7% of the world's total, with Southern Africa contributing less

than 2%. South Africa accounts for a high proportion of emissions in the region for instance, it accounts for 89% of the region's CO_2 and this is mostly from energy related activities. However, others have indicated that despite the apparent low rates of greenhouse gases, in Southern Africa, a combination of urban and biomass burning emission of aerosols and trace gases plus the circulation of natural dust have a potential to have significant influence of climate processes over the region (Tyson et al, 2002).

The indicated climate changes will affect biophysical processes with implications on the supply of environmental resources and ultimately food security among communities of Southern Africa. This is of major concern given the already rising pressure on natural resources. Further, adaptation capacity to climate change is defined by progress in socio-economic development and as a result the widespread poverty in the region is an indication of the high level of vulnerability to climate change (Parikh, 2000). The overall impacts of global environmental change for southern African food provision noted in the literature include the following (Tyson et al, 2003):

- Changes in agricultural production belts. The area for sorghum production appears robust, but maize and several trees species are expected to be more affected and vulnerable;
- Productivity advantages of C3 over C4 crops and plants, with the C4 group more favoured;
- The productivity of rangelands is closely related to rainfall patterns. Productivity is expected to decline in the southern parts where rainfall is likely to decrease and become more variable;
- A decrease of quality of rangelands in southern Africa; but better rangeland conditions in north-west and south-eastern parts of the region;
- The water cycle and supply will change at a time when is water demand is rapidly increasing;
- GEC will affect commercial and subsistence agriculture. However, the former is better able to adapt, even though the costs may be considerable;
- Poverty is expected to increase in adversely affected areas, further eroding adaptation capabilities;
- GEC will have positive and negative impacts on food production and provision. It is expected that Namibia, Botswana and Eastern Zimbabwe and South Africa will be negatively affected. In contrast, the productive potential of the northern part of SADC region may increase, emphasising the importance of specialisation of food production and increased intra-regional trade.

The high uncertainty and high level of generalisation of expected impacts of climate + Change at regional, national to local level constrain attempts by policy makers to plan strategic adaptation measures for specific areas. For example, there is need for more focused information on how climate change will affect rainfall bearing systems such as the Inter tropical Convergence Zone, the Indian Ocean air masses and the ENSO events and how this will change the spatial distribution of rainfall within a country.

From the current situation it is clear that a southern African GECAFS project needs to study/ document the detailed impacts of GEC on the region, as these appear not or poorly understood. The current consensus seems to be that the southern-central parts will be disadvantaged, while the northern and eastern parts may benefit. It could therefore be argued that a GECAFS project should concentrate on the hotspots or affected areas (e.g. Namibia, Botswana and parts of South Africa and Zimbabwe), but at

the same time incorporate constraints and opportunities for intra-regional trade (from surplus to shortage areas).

2.3 Environmental and development challenges

The above sections clearly show that GEC will be an important addition to the many existing stresses on food provision in the region. Of all the continents, Africa will be among the most severely affected by climate change (IPCC, 2001). It is therefore necessary to outline the major challenges that may have a bearing on future food provision in southern Africa. Below are development and environmental challenges that need to be addressed to help reduce vulnerability within the region. Following these are regional initiatives that help food provision (section 3).

Development challenges and commitments:

- Reducing the number of hungry people by half in 2015 (cf. 1996; World Food Summit 1996 and Millennium Development Goal)
- Reducing poverty by half in period by 2015 (Millennium Development Goal);
- Accelerate economic and agricultural growth and diversification (see NEPAD and SADC plans; section 3);
- Integrate principles of sustainable development into country's policies and programmes and reverse loss of environmental resources (Millennium Development Goal);
- Halve by 2015 the proportion of people without sustainable drinking water and basic sanitation;
- Expand, improve and maintain educational, health and communication infrastructure and standards;
- Increase political and economic stability of individual countries;
- Increase regional integration and trade to increase competitiveness and boost growth and development;

Environmental challenges:

- Improve resource management in the subsistence sector to reduce environmental pressure;
- Encourage economic specialisation, including food production, based on comparative environmental advantages;
- Increase the productivity of natural resource use;
- Meet international commitments of global and regional conventions;
- Improve national and regional management of water resources in support of human development and economic growth;

3. SADC and NEPAD and other regional initiatives in improving food security and production

3.1 SADC

The overall goal of SADC is to foster economic growth and eliminate poverty through regional integration and trade. Sustainable food security is one of the priorities of the *Regional Indicative Strategic Development Plan (RISDP).* Other priorities include: HIV/AIDS; gender equality and development; trade, liberalisation and development; infrastructure support; science and technology and human and social development.

SADC adopted a *Food Security Strategy Framework (FSSF)* in 1997. The Framework emphasised access to food and the demand side of food security. Poverty and under-development are seen as root causes of food insecurity, and need to be addressed. According to the Annual Report 2001/02 of SADC (SADC, 2003), economic growth will have to exceed 7% per annum in order to reduce poverty in the region. The objectives of the FSSF are to:

- Improve access to food;
- Increase the availability of food;
- Improve the nutritional status of people in the region.

The agricultural sector is considered to be part of broader development planning.

The FSSF has six components, including agricultural research, crop production, livestock production, marine and inland fisheries, forestry and wildlife. New programmes include the SADC Food Security and Rural Development Hub, the Regional Programme for Communication for Development (RPCD); and Agricultural Potential Information System (APIS).

New measures to reduce food shortages include the allocation of more funds to agriculture, provide food relief to the vulnerable groups, winter cropping, irrigation and drought recovery programmes to allow farmers to be back in action soon after droughts subside (SADC, 2003). High transport costs in the region, limited marketing infrastructure and trade distortions are considered to be major constraints for increased food production. Harmonisation of legislation to facilitate intra-regional trade is a priority (SADC, 2003).

The SADC region has a high, but under-utilised potential for fisheries. The potential regional catch could be around 3.5 million tonnes, of which 29 would originate from inland waters. About 250 million hectares of land is considered suitable for aquaculture development (SADC, 2003).

Priority areas for agricultural research are (SADC, 2003)
:

- Improvement of sustainable market oriented smallholder production;
- Training and empowerment of rural development, and information/ communication management;
- Sustainable management of natural resources; and
- Regional training.

Late February 2004, SADC countries reached agreement about the establishment of a regional grain reserve. Political hesitation has long affected the establishment of a SADC Regional Strategic Grain Reserve. Despite the general trend towards trade liberalisation, discussions about regional specialisation based on comparative advantages in food production and food trade are in their infancy. The region is still stuck on matters of national identity, sovereignty and national food security as opposed to regional food security.

Agricultural Potential and Trade Information System (APIS), one of the initiatives within SADC is in particular is highly relevant to GECAFS and vice versa (see figure 5)

Figure 6: A profile of the APIS project

The Agricultural Potential and Trade Information System (APIS) will provide a powerful tool to support decision-making to resolve the issue of food shortages in the region. The programme is to be institutionalised within the SADC Food Agriculture and Natural Resources Commission (FANR).

The project has been funded by the DBSA and is carried out by the University of Stellenbosch

The APIS is intended to support and contribute to the following pillars of the NEPAD continental and regional action plans: Agriculture – Capacity Building; Market access and diversification of production – Policy Formulation; and Regional integration – Policy Formulation and Capacity Building.

Phase 1: detailed socio-economic description of the individual SADC countries.
Phase 2: development of a capacity to generate information on agricultural resources as well as their use for production. The vast amount of data on the agricultural resources has been captured in a geo-referenced information system, using GIS technology. This information system can be used to retrieve and manipulate the information according to specific needs, for example to determine the quantity and location of various classes or qualities of arable land and areas suitable for a particular crop.
Phase 3: The output of Phase III is a land suitability model, in combination with a transport model, to provide tools for scenario development with regard to future spatial patterns of production and distribution based on land potential and current or future transport infrastructure
Phase 4: the main issue that needs to be addressed under APIS IV is "What do the SADC countries need which this model can assist with and how can these needs be met?"

GECAFS questions:

1. What and how can GECAFS use this model for the benefit of the SADC countries and NEPAD as a whole?"
2. How can a regional GECAFS add value to the APIS model?

Some possible contributions of GECAFS:

1. The APIS model so far developed gives a basis on which one can do a whole range of "what if" analyse, particularly in terms of crop production factors using existing datasets. What would be of significant interest to GECAFS would be to do "what if" analyses on Climate Change using this model that incorporates crop production and accessibility of that food to various populations in the region. This analysis has not yet been done on climate change and therefore a potential challenge for GECAFS not only to infer the impact of GEC but to also participate in regional skills development through a researcher student or some such programme.

2. Contributions to capacity building in region
3. Selection of drought tolerant crops for further analysis
4. Incorporation of social, institutional and trade issues into the model

3.2 NEPAD[3]

The NEPAD's Africa Comprehensive Agricultural Development Programme (CAADP) aims to revive agricultural development and by doing so cut hunger, reduce poverty, boost economic growth and boost the balance of trade.

The most telling statistic regarding food provision is that the number of hungry people in Africa has increased from 173 million in 1990-92 to 200 million people in 1997/98 or 28% of the total population. Imports of food have risen fast, and amounted to US$ 18.7 billion in 2000. In Sub-Saharan Africa more than a third of the population is classified as malnourished. The World Food Programme (WFP) of the UN has spent US$12.5 billion in Africa during its period of operation representing 45% of its total investments. Its presence in the region seems almost permanent rather than an emergency event.

Africa's economic problems are caused by lack of agricultural growth and development as well as the lack of other growth engines, particularly industry and services. The combination of sluggish agricultural and overall economic growth has led to economic stagnation with a decline in food provision (other than through food aid). According to Eicher (2003), NEPAD should focus on mobilising African and donor investment in genetic and agronomic research of Africa's eight major food staples because reducing food prices is the most promising avenue for reducing mass poverty in Africa"

NEPAD's CAADP is founded on four pillars, related to production and distribution/ accessibility of food:

1. Expansion of the area under sustainable land management and reliable water control systems;
2. Improving rural infrastructure and trade-related capacities for market access;
3. Increasing food supply and reducing hunger, including responses to disasters and emergencies and the establishment of safety nets; and
4. Agricultural research, technology dissemination and adoption. It is realised that progress in this area has mostly long-term benefits.

The Plan requires an annual investment of US$ 17.9 billion, close to the value of annual food imports. Below, we briefly summarise each 'pillar'.

Pillar 1: Sustainable land management and water control systems
Reliance on irregular and unreliable rainfall for agricultural production is a major constraint on crop productivity. Rain fed agriculture is usually unsuitable to achieve the full potential of high-yield crop varieties. Irrigation is relatively small in southern Africa, and many irrigation projects have collapsed. NEPAD believes that the first pillar to assist in the improvement of Africa's agriculture, food security and trade balance is to extend

[3] NEPAD is a continent wide development plan. The position of southern Africa does not differ fundamentally from that of the rest of the continent.

the area under sustainable land management and reliable water control systems (e.g. irrigation). This strategy involves:

- Building up soil fertility and moisture holding capacity of agricultural soils; and
- Rapidly increasing the area equipped with irrigation, especially small-scale water control units. This involves the rehabilitation of irrigation schemes and establishment of new schemes.

Pillar 2: Rural infrastructure and trade-related capacities
Improvements in roads, storage, markets, packaging and handling systems, and input supply networks, are vital to improving the competitiveness of local production on the domestic and global markets. Investments in these areas will stimulate the volume of production and trade, thereby assisting to generate an appropriate rate of return on needed investments in ports and other facilities.

This strategy involves:

- Infrastructural improvements in view of the long distances to markets and the fact that a fifth of Africa's population is landlocked;
- Adjustments in the promotion and support (including subsidy) policies of developed countries; and
- Raising the capacity of SADC exporting countries to participate in trade negotiations and to meet stringent quality requirements of world trade.

Pillar 3: Increasing food supply and reducing hunger
Africa currently lags behind other regions in terms of farm productivity levels, with depressed crop and livestock yields and limited use of irrigation and other inputs (e.g. fertiliser). Productivity improvement in this area can be achieved through:

- Accessing improved technology to allow small farmers to increase food availability close to where it is most needed and to raise their incomes;
- The provision of improved farm support services; and
- A supportive policy environment.

The proposed activities will be closely linked to the Food and Agricultural Organisation (FAO) of the UN and SADC strategy of regional and national food security frameworks.

Pillar 4: Agricultural research, technology dissemination and adoption
This pillar aims at achieving accelerated gains in productivity. To achieve this, the continent will require:

- An enhanced rate of adoption of promising technologies through better linkages between research and extension on the one hand and producers on the other hand;
- Technology delivery systems that rapidly bring innovations to farmers and agribusinesses, thereby making increased adoption possible;
- Renewing the ability of agricultural research systems to efficiently and effectively generate and adapt new knowledge and technologies, including biotechnology; and
- Mechanisms to reduce costs and risks of adopting new technologies.

3.3The Consultative Group on International Agricultural Research (CGIAR)

While food aid, better rural services and poverty reduction are important to improve livelihoods, they do not directly increase crop yields and food provision. Therefore, there is need to increase agricultural research and innovations to increase agricultural productivity and production (Eicher, 2003).

Deriving from the above, and within GECAFS' context with particular regard to biophysical factors of production, efforts to reduce poverty in southern Africa should address crop yields, enhanced technological and institutional innovations and continued agricultural research.

The Consultative Group on International Agricultural Research (CGIAR) addresses these very issues of agricultural research, innovations and production through its International Maize and Wheat Improvement Centre (CIMMYT) and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), which conducts research, into sustainable production increases of six drought tolerant crops (sorghum, pearl millet, finger millet, chickpea, pigeon pea, and groundnuts) and into improved management of the limited natural resources of the Semi-arid tropical countries.

ICRISAT has focused on sorghum and millet research and training, with USAID funds for activities in southern Africa (now ended). ICRISAT also participates in several regional projects that address important crop issues in semi-arid environments: risk management by smallholder farmers; soil fertility management programme; impact assessments of HIV/AIDS and disease control; and desertification and poverty. Risk management will be discussed in more detail below.

Farmers' risks
The impact of these programmes is essentially to provide the means, in the form of appropriate genetic and technological innovations through research and the production of high-yielding and drought tolerant crops, to encourage maximisation of comparative advantage in food production and therefore food provision.

GEC is expected to increase farmers' risks, and therefore it is necessary to *understand risk management strategies of farmers* and to assist farmers with risk management, e.g. by providing timely information about the risks and ways of handling risks, and by creating an environment that offers incentives for appropriate adaptations.

Generally, farmers are very risk averse and therefore their decisions may not be in line with overall and broader desired national objectives. It is therefore extremely important that the farmer be provided with timely, accurate, relevant and quality information that reduces their risks and assists them in taking optimal farmer decisions in relation to production strategies.

3.6 Other regional programmes

Below, the activities of the USAID Centre for Southern Africa and the UN-activities are discussed in more detail. The EU and DFID-UK are the other major regional donors.

The focus of the EU programme lies on regional integration, trade, transportation and communication, hence trade and distributional aspects of food provision. DIFID focuses on poverty elimination in the SACU countries and SADC. Programmatic priorities include food security and others such as trade, water resources and HIV/AIDS.

Most donors assist with drought and famine relief.

USAID Regional Centre for Southern Africa
The Regional Centre for Southern Africa (RCSA) is charged with the implementation of the Initiative for Southern Africa. The goal is to promote equitable, sustainable growth in a democratic southern Africa. The new document is written to concur with the objectives of NEPAD as well as US foreign policy interest in Africa (USAID-RCSA, 2003).

The first Regional Strategy is currently being completed (1997-2003) and the second regional strategy (2004-2010) will start in September 2004. The new Strategic Plan has a strong market focus, encourages public private sector partnerships, and supports activities that serve American political and economic interests. The Plan has four strategic objectives/ themes:

1. More competitive southern African economy, including capacity building, boost export firms and support policy and institutional change that increase the region's competitiveness;
2. Rural livelihood diversification, including assistance to budding commercial farmers to export high value crops, diversify crop-livestock systems and to coordinate regional agricultural development and rural livelihood research and policy. This objective is directly linked with the separate President's Initiative to Eradicate Hunger in Africa;
3. Improved electoral competition in southern Africa;
4. Improved management of selected river basins, including strengthening the capacities of regional river basin committees and policy reforms, development of capacity of communities living in watersheds to manage water and ecological resources in a sustainable manner.

The first and second themes are most important to GECAFS. The Okavango river basin has been selected for theme 4, and would be most important for food provision in Angola. The planned key areas for action and possible activities for the relevant themes are summarised in Table 11.

Food insecurity is listed among the major challenges for southern Africa in addition to macroeconomic instability and water scarcity. Food crises are seen as livelihood crises due to underlying problems such as poverty, malnutrition and declining investment in agricultural research and technology.

HIV/AIDS, gender, corruption, conflict mitigation, environment, and public-private sector partnerships are crosscutting issues for the new Strategy.

Programmatic collaboration between USAID-RCSA and SADC is at present difficult because of disagreement about the handling of Zimbabwe.

Table 11: Key objectives, result areas and possible activities for the new USAID RCSA strategy.

Objective	Intermediate result area	Possible activities
Increasing competitiveness	1. Enhance policy and regulatory environment for free trade and competition	Competitiveness hub Support for trade negotiations (e.g. US-SACU FTA)
	2. Strengthen capacity of targeted clusters to produce and market competitive goods	Value-adding export relationships developed within the region and internationally Increased access by cluster enterprises to inputs, business development services, credit, and export finance Cluster goods and services meet labor, environmental, quality, and safety standards of export markets
	3. Reduce the key transaction costs, particularly at border posts	Improved efficiency and transparency of customs, transit, and trade facilitation operations Improved efficiency and transparency of international financial transactions Increased private investment in economic infrastructure
Rural livelihoods Diversification	1. Export by emerging commercial farmers of high value agricultural crops	Adoption of yield-enhancing technologies Meeting quality and safety standards for selected agricultural commodities Commodity chains link
	2. Diversification of agricultural production in pilot vulnerable communities	Promotion of appropriate production systems Mitigation strategies for impact of HIV/AIDS on agricultural sector
	3. Improved regional coordination of research and policy	Public-private sector investment in market-led agricultural research Public-private sector partnerships to reform agricultural trade and investment policies Synergies and complementarities from research coordination
Improved management of selected river basins	1. Strengthening of institutional capacity	Legal and regulatory reform Use of analytical and management tools
	2. Improved community management of critical hydrological areas	Community-based enterprise development Increased community participation in water management

Source; USAID-RCSA, 2003.

3.7 GECAFS' role in Southern Africa

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 big enough and diverse enough to be a stand-alone economic zone and therefore regionalisation provides a possible key to the region's food provision systems and therefore food security.

Southern Africa is unique for GECAFS as food insecurity is a growing problem in southern Africa, and for many countries within the region. Existing regional efforts on food provision are mostly short-term oriented, aiming to revive agricultural growth and development. Governments and donors seem to agree on several consensus priorities

such as poverty reduction, food security increases, adoption of improved agricultural technologies, improving market access of small farmers, establishment of a better agricultural support infrastructure and increased funding however, practical implementation of programmes to address these priorities is yet to be realised. The potential of irrigation, emphasised in NEPAD-CAADP is more controversial, as questions are raised about the adequacy (and costs) of water supplies and about the past failures of many irrigation schemes. It should be acknowledged that agricultural research and technological development of the past have been unable to stimulate agricultural growth and production, and there is need to understand what went wrong.

The relationship between food security and GEC is not mentioned in southern African plans and programmes such as the NEPAD and SADC, except in the new regional Strategy for USAID. Therefore the biggest contribution that GECAFS can make is to examine the longer-term relations between GEC and food security in southern Africa. In other words, GECAFS would add GEC to existing food provision and security strategies.

This is particularly important in the following areas that are vital to food security:

- Risk assessment, and farmer risk reduction and minimisation strategies in production strategies;
- Provision and development of larger agricultural production capacities (intensive agricultural production systems) coupled with corresponding agro-processing systems that can help ensure all-year-round supply of the desired tradable commodities; and
- Assist with socio-economic factors such as vulnerability from various points of view including issues affecting health and general livelihoods.

A GECAFS project in southern Africa finds a fruitful policy platform, as is evident from the policy concerns addressed by SADC and NEPAD. Livelihood and food security has a high priority, and this extend to donors such as USAID and DFID. Therefore, the results of a southern African GECAFS intervention could make real contributions to SADC and NEPAD.

Little regional research is carried out on food provision and global environmental change. While some opportunities exist to add on to existing research programmes (ICRISAT and APIS), new integrative research is needed to address the three key themes of GECAFS.

4 Possible impacts of GEC on food provision and vulnerability in Southern Africa

Deleted: additional

This section reviews the issues related to possible impacts of GEC on food provision, as derived from reports and interviews that are particularly relevant to southern Africa. While at a global level there is adequate evidence of GEC, there is still a great deal of uncertainty on how GEC will manifest itself at the local level and about its possible impacts, constraining local and regional policy makers in their actions. However, as governments and regional organisations plan to invest heavily in agricultural revival, it is important to ensure that the investments, research and infrastructure remain efficient under conditions of GEC.

4.1 Determinants of food provision other than GEC

The failure of African agriculture has been attributed to a wide range of factors, the most important ones are summarised in Table 12.

Table 12: Determinants of production, distribution and access to food.

Determinant	Food production	Food distribution	Economic access
HIV/AIDS	Low productivity Labour shortage	Less investments	Reduced available income
Poverty	Low productivity and skill		Low ability to purchase food
Land tenure and distribution	Reduced production		Reduced access to finance
Governance-stability	Reduced Investments by both regional governments and donors	Investments Maintenance of grain reserve	Reduced investments
Inadequate infrastructure	Limited input availability and opportunities to sell	Difficult to move surpluses to shortage areas	Higher transaction costs
Agricultural policies	Lacking long-term projection		Reduce self-sufficiency
Water availability-stress	Major production factor		
Access to global markets	Restricted access and western agricultural subsidies reduce export opportunities	Availability of food surpluses Global prices	
Population pressure (human and livestock)	Land shortages		
Land use changes-degradation	Reduced productive potential		
Access to input markets	Reduced input application rates, therefore reduced production		

Sources: interviews and literature.

Currently, the non-GEC factors combined have a much greater impact on food provision than GEC. This could be considered as an extra handicap, but is in fact a long-term opportunity to cope with the impacts of GEC on food provision. Successfully dealing with other constraints of food provision could allow better food provision even with GEC, as the region will become less vulnerable.

4.2 Possible impacts of food production

As details of GEC, particularly future climate changes for the region are limited, it is obviously difficult to predict possible impacts on food production. Attempts to establish likely impacts on food provision are also confounded by limited availability of necessary

historical data, for instance crop yields or temporal patterns of plant species composition in rangelands. A detailed assessment of GEC on the major food products of the region is therefore an important activity for GECAFS. The overall major impacts are expected to be:

- Changes in comparative advantages and production belts in southern Africa;
- Greater variability (spatially, seasonally and inter-annually) in production, and hence increased farmers' risks;
- Changes in the water cycle and agricultural water availability. Increased water stress, particularly in southern parts; and
- Changes in pests affecting production.
- Changes in the quality of rangelands affecting livestock and wildlife population

Below, the possible impacts on crop production, livestock and wildlife, fisheries and veld products are discussed in some more detail.

Over 50% of the population of Southern Africa depend on the agricultural sector. Agriculture is a high volume user of water, accounting for over 80% of water in sub Saharan Africa (Magadza, 1995; Sharma et al., 1996). Competition for water will be growing in future, and it is unlikely that agriculture will continue to receive such a large portion of water resources, as long as the agricultural value added per cubic meter remains low (Arntzen et.al, 2003).

I. Warm temperatures and poor rainfall resulting from climate change will cancel out the expected benefits from increased CO_2 on plant water and nitrogen use efficiency (Schulze et al, 1995).

The effect of warm temperatures on crops will vary for different crops and soil types. A comparison of maize and sorghum yields over the Kalahari sandveld and loamy soil hardveld parts of Botswana showed that there is likely to be greater decline in yields in the sandveld than in the hardveld for both crops which increases with temperature but this will affect most maize than sorghum (Table 13).

Table 13: Projected change in maize and sorghum for 2 to 3^0 C increase in temperature under different soil types in Botswana.

	Hard veld (loamy soil)				Sand veld (sandy soil)			
Temp.	Yields		Growing time		Yields		Growing time	
	Maize	Sorg-hum	Maize	Sorghum	Maize	Sorg-hum	Maize	Sorg-hum
2^0C	-23.3%	- 4.7%	-13.6%	-9.3%	- 21.6	-16.1%	-13.8%	-12.4%
3^0C	-32.6%	-7.5%-	-18.6%	-14.2%	-35.8%	-25.6%	-19.4%	-17.0%

Source: Chipanshi et al, 2003.

Sorghum: A healthy sorghum crop for instance, needs nearly 300mm of water at the root-zone. For semi-arid zones such as Botswana the chance for this to happen is already limited under the current climate regime (Bhalotra, 1989). Under climate change crops will be water stressed most of the time due to high evapo-transpiration and this will reduce the chance to establish optimum yields for rain fed agriculture in arid areas. However, a drier climate will favour sorghum and millet than maize.

Maize: Over the past decades maize has grown to be the most preferred cereal over sorghum in the region, even though large parts are unsuitable for its production. Maize is less drought resistant and significant decline in yields under the projected climate change have been indicated. In addition to rainfall, nitrogen stress can reduce maize yields to less than one third of the nitrogen un-limited maize yields (Schulze et al., 1995). This means that the effect of climate change on maize yields could be severe under the widespread small-scale subsistence farming where fertilizers are rarely applied.

II. Climate change may also shorten the growing season in general. For Botswana, the current length of the growing season is described as uneconomical even in the wetter northern parts. On average, 110 to 130 days are required for maize and sorghum (Bhalotra, 1989).

However, the effect of climate change on both maize and sorghum will vary spatially with soil types.

Livestock, wildlife and veld products: Livestock, wildlife and veld products have a significant role in the diet of the Southern Africa population. Initial assessment of impacts of climate change project a net loss in biodiversity, with implication on availability of veld products, fodder for domestic animals, and wildlife habitat (Rutherford et al., 1999).

III. A warmer and drier climate coupled with an elevated CO_2 will favour the spread of woody plants relative to non-woody plants. Pronounced climate extremes, particularly, severe droughts alternating with periods of high rainfall will enhance the ongoing process of bush encroachment in the region.

*Livestock: L*ivestock production is a major component of the agricultural sector in Southern Africa, particularly in countries such as Botswana where crop production is not viable. Beef contributes on average 55-65% of the agricultural output every year in Lesotho (Ministry of Natural Resources, 2000). Projected increase in bush encroachment will lead to a loss of nutritious grass species and the spread of hardy less nutritious varieties. This may increase production advantages of goats and other small stock as well as from game farming. Increased growth in grass in response to CO_2 is known to come with a decrease in nitrogen content, which is already a limiting factor in animal production in Africa. It is likely that there will be a greater need to rely on supplementary feeding under future climate change.

Wildlife: An increase in shrubs relative to woodlands will negatively affect the habitat of the large mammals found in this region. A link between the metabolic biomass of large herbivores and rainfall shows that a habitat dominated by shrub land will not favour mammals such as elephants, antelopes and hippopotamus. This has implications of the nature-based tourism that currently depends on such species. Land use pressure during drought periods will add another stress on the habitat of wildlife, as already demonstrated under current climate conditions. Effective monitoring of wildlife species and their habitat is required to detect early changes and consider measures for intervention.

Veld products: All things being equal a drier climate will support medicinal veld products such as grapple plant (Harpagophytum procumbens) and shrub species such as *Grewia flava*, which produce edible fruits (Chanda et al., 2000; Ministry of Natural Resources, 2000). However, hot dry weather will increase the frequency of severe fires particularly

after wet periods and this will cancel out some of these positive developments. It is also not clear how bush encroachment in place of woodlands and forests might influence the productivity of Phane caterpillar and the availability of fuel wood, both of which are part of the Southern Africa food system. An effective biodiversity monitoring system involving a network of long-term ecological research sites in the region is required to monitor change in natural systems for climate change preparedness (Rutherford et al., 1999).

Fisheries: Fish is an important protein supply for a number of communities living along rivers, wetlands and lakes of Southern Africa and has grown to be an important source of income over the past decades.

One likely positive impact of climate change on fisheries is that subject to availability of water and food, a rise in temperature could shorten the maturity period of some of the fish species, for instance the tilapia. Temperature may also increase the reproduction of crocodiles (Magadza, 1995). However, a decline in water supply in wetlands, dams and other reservoirs due to high temperatures coupled with siltation and pollution from land use will in general, negatively affect the fresh water fish industry.

Marine fishery generates around 588 million Euros per year in southern Africa and forms the major source of foreign exchange in Namibia and Mozambique (SADC, 1997). Fish catch from 1960 and 1980s have fluctuated between 2 to 3 million tones per year between the Benguela up-welling on the west and the Agulhas system on the East Coast.

IV. Extreme climate events, particularly over the wet humid periods, will provide favourable breeding conditions for pests with consequences on food production. Locusts tend to reach high proportions during or after droughts. Initial assessments showed that the distribution of tsetse fly might be reduced while ticks could increase in the north westerns part of the region (Tyson, et al, 2002). It is also likely that in addition to bush encroachment mentioned above, other poisonous plant species could increase and reduce the population of wildlife and or domestic animals. Precise information on the likely effect of pests on food systems under climate change is needed to guide policy.

V. Links have been made between the depositions of iron rich dust from Southern Africa landmass into the Indian Ocean with the increased production of phytoplankton (Tyson et al, 2002), an indication of the potential impacts from in-land land use activity on fisheries. Changes in wind stress on the surface and up welling, which could change under future climate changes, influence change in the west coast marine biology. For instance, the weakening of the up welling could lead to increased levels of harmful algal blooms. There is also a potential for increased ultra violet radiation to inhibit photosynthesis in the sea leading to a regional decline in phytoplankton biomass (Shannon et al, 1990). A marked decline in fish catch in Namibia was noted in the past such that by 1981 the pilchard processing plant in Walvis Bay had to close down (SADC, 1997).

4.3 Impact on food distribution, trade and food aid

Damage to infrastructure is expected to increase, as the existing infrastructure is not built to deal with more frequent and severe floods and extreme temperatures. When

damage is not repaired, the resulting impacts on food distribution become substantial and lasting.

Trade and food aid are expected to increase due to the growing gap in agricultural production potential between surplus and deficit areas. This is expected to put pressure on existing road, rail and communication infrastructure in the region, large parts of which require urgent maintenance.

Information on the likely impacts of climate change on the six food transport corridors is limited although the potential impact of climate change on coastal areas is recognised internationally (IPCC, 2001). In Madagascar deposition of sediments has rendered the Mahajanga port useless while in Mozambique large volumes of sediments deposited by rivers have formed huge sand banks and extended Deltas (Sharma et al, 1996). Increased processes of land degradation in the mainland as a result of the effect of climate change on land use intensity will exacerbate this process.

Where countries or consumers cannot afford to purchase food, food aid will grow, and become more frequent. This trend is already discernable at the local and national level. The success of provision of food aid obviously depends on availability of maintained and adequate distribution and communication networks.

4.4 Impacts on livelihoods and food security

Given the lack of detailed knowledge about GEC in southern Africa and its impact on food production and distribution, the impacts on livelihoods and food security can only be indicated in general terms. The majority of small farmers in southern Africa are unable to meet all their needs, and therefore have a short-term horizon. GEC is an additional factor that may intensify their livelihood struggle.

Most inhabitants of southern Africa will experience a decrease in crop and livestock production that can only be prevented by proper adaptations. As most of these are associated with higher production costs , livelihoods will be adversely affected. Those living in countries with good governance and economic performance are expected to be less affected, as they may be able to purchase food from non-agricultural sources of livelihood and government assistance programmes. Those living in countries with economic and governance problems have nothing to fall back on, and ultimately depend on international food aid.

Key factors in analysing the livelihood and food security impacts of GEC are therefore:

- livelihood strategies and diversification. The more diverse the livelihood sources, the small the negative impacts of GEC on overall livelihoods will be;
- the level of livelihood and livelihood assets. Greater poverty and non-ownership of assets makes households more vulnerable;
- An educated and informed community is in a better position to make appropriate livelihood improvement decisions;
- Governance and macro-economic performance of countries determines the severity of impacts on livelihoods, as they determine government's opportunities to provide assistance.

Households in northern parts of the SADC region will be better off when the productive potential increases, and they are able to increase productivity. The latter requires prudent food production techniques.

A key livelihood concern for GECAFS should be the identification of vulnerable areas/ countries and vulnerable groups in society. Some responses from interviewees and the literature are summarised in figure 6.

Figure 6: Vulnerability groups and hotspots

Vulnerable groups are generally:

- households with low-incomes and/or few assets (income, capacity and participation poverty);
- households that primarily depend on food production, and live in an affected area;
- households that depend on areas with degraded natural resources;
- Female-headed households, orphan-headed households and ethnic minority groups.

Vulnerable commercial farmers are those that:

- Have become dependent on agricultural subsidies;
- Have eroded their natural resource base.

Vulnerable areas:

- Semi-arid/ arid land, particularly those on poor soils and used for food production in southern Africa. These areas are expected to become hotter and drier;
- Remote dry, densely populated areas with a minimal potential to increase food production.

Source: based on interviews

4.5 Impacts on other aspects relevant to food production

Some of the most important aspects in attaining food security are availability of clean water and a healthy population. The two aspects are considered here.

Water resources

Water is a critical commodity, as it has a potential to constrain all food security activities including mining and cultural tourism that could be adopted to alleviate climate change and other stress on food production. Under current climate conditions South Africa could reach limits of its water availability by 2030 (Conley, 1997); many other southern African countries also face water scarcity (SADC, 2001). The projected increase in temperature and general decline in rainfall over most of the region will exacerbate the already observed shortage of water in the region and this will have negative consequences on the food system of Southern Africa [4].

The rise in temperature will result in reduction of runoff and stream flow affecting most river basins in arid and semi-arid areas such as the Limpopo in Botswana and south

[4] Evapo-transpiration rates increase by 3 to 4% for every 1^0 C rise in temperature (Pisani and Partridge, 1990; Schulze et al, 1995).

western Zimbabwe where evaporation rates are already high (Magadza, 1995). The mean potential evaporation varies between 1400 and 2200mm over the 1750 km long Limpopo river (Boroto, 2001). Prospects for irrigation as an adaptation strategy will be minimised affecting some of the agriculture initiatives under NEPAD

Processes of land degradation, which are likely to accelerate over dry periods, will further reduce water availability. Land degradation leads to high siltation in tributaries feeding into large rivers, which reduces the capacity of reservoirs, and may alter streambeds and increase the probability of flooding in wet periods. Deteriorating infiltration capacity due to land degradation also leads to reduction in underground water recharge over time. This may result in salinity, a process that has already been noted in some parts of Southern Africa (Conley, 1997). Such changes will negatively affect the livestock industry. In semi-arid areas livestock is already dependent on ground water resources under the present climate conditions.

As most surface water sources are shared among countries, water scarcity may lead to political instability, which constrain further attempts to address food provision (Boroto, 2001). Differences on shared basins have already been noted, for instance the land use pressure in the Kavango District in Namibia and the effect of this on the Okavango swamps in Botswana in the long run (Moyo et al., 1993).

Health
A healthy society is required to achieve food provision and vice versa. Initial assessments of impacts of climate change indicate that human health is likely to be compromised by climate change (IPCC, 2001).

Nutritional deficiency due to frequent crop failures will be prevalent as demonstrated in the past over periods of drought under the current climate (Buchanan, 1998).

Shortage of water will increase health issues associated with water pollution, which is already a growing problem in major cities and settlements of Southern Africa (Chanda, 2000). The potential of outbreaks of water-borne diseases such as cholera, intestinal worms and typhoid will also increase. Cholera outbreaks were reported in Zimbabwe during the 1991/92 drought and a number of SADC countries reported outbreaks for the 2000/2001 wet season. These potential health problems could give rise to the worst scenario for food provision when combined with HIV/AIDS, which already has devastating impact on the economies of Southern Africa.

Another potential health problem that may result from extreme climate events will be the spread of pests, which will attack food production, storage and also directly lead to certain diseases. For instance *trypanosomiasis* from tsetse fly can attack both human and their livestock. Increased relative humidity in wet periods due to warm temperatures will provide optimum conditions for mosquito reproduction. During the 1999/2000 floods, malaria-carrying mosquitoes extended further south in Botswana. In Zimbabwe it has been projected that malaria transmission potential will increase into high altitude areas, which normally are less affected (Martens, 1998).

4.6 Proposed key issues for theme 1

From the above discussions of GEC impacts, the following issues emerged as important for a possible GECAFS intervention in southern Africa.

1. Integrating long-term GEC concerns and impacts in the short-term struggle to improve food production, distribution and provision;
2. Detailed assessment of GEC on the major food products of the region;
3. Detailed assessment of expected GEC impacts on the transport and food distribution infrastructure;
4. Establishing an inventory of traditional knowledge on past GEC and vulnerabilities experienced then;
5. Inventory of traditional knowledge and (global) environmental change
6. Vulnerability assessment to future GEC: identification of the vulnerable areas, groups and products (crops and animals);
7. Shifts in production belts/ comparative advantages of major crops (e.g. cassave/ sorghum) and animals (small stock-cattle);
8. Potential for new income-generating products (non-conventional crops and game);
9. Changes in water availability (also bearing in mind growing competition for water) and requirements;
10. Identification of the areas with enhanced and reduced food production potential due to GEC, and ensuring that this potential is exploited to the benefit of intra-regional trade.

5 How might societies and categories of producers adapt their food systems to cope with GEC?

Adaptations to GEC have to be understood within the broader context of changes in consumer demands. Therefore, this section first deals with changes in consumer demand (5.1), before various types of adaptations will be reviewed section 5.2.

5.1 Changes in consumer demand

Changes in demand are poorly documented, but urbanisation and welfare improvements are believed to drive such changes. Considerable differences exist in food consumption among countries. According to SADC-FANR data, milk consumption ranges from as low as 3 L/person/year in Malawi to 59L/person/year in South Africa and Botswana. Per capita beef consumption is highest in Botswana, Mauritius and South Africa.

Most southern African consumers, particularly in urban areas, prefer maize and rice above sorghum and millet, even though local physical conditions are often unsuitable for the former. There seems to be a growing disparity between what can be locally grown and what is locally produced, posing the challenge to decision-makers whether consumer preferences or basic needs need to be addressed. Interviews also highlighted the fact that some of the preferences are influenced by need to reduce the cost of energy, for example sorghum requires more energy to cook in contrast to rice.

Veldproducts and game have a high nutritional value and are well adapted to local environmental conditions. However, consumption of game meat and veldproducts has declined due to a variety of factors. Hunting is banned or strictly regulated in most of southern Africa, and many veld products have become scarcer and less easily accessible. Living conditions have improved, and permit consumer to purchase commodities in shops, which have a higher ‘prestige’. Consequently, increases in welfare tend to lead to a decrease in the consumption of game meat and veldproducts, and an increase in consumption of cereals and beef/ goat meat.

Increased food imports and drought, which reduces availability of local food products, has led to an increase in western food products. Sugar, tea, rice, oils and wheat products have become an integral part of the diet of every household in southern Africa. The staple cereals such as maize and sorghum are normally consumed with vegetables such as potatoes, cabbage, spinach, onions and tomatoes either as part of the meat dish or on their own as relish. In addition, fruits such as oranges and apples, eaten directly or served as fruit juice have become an important part of the family diet in urban areas. An inventory of sources of these additional food items with information on major suppliers, handling and distribution facilities is needed to help consider future changes. Fruits and vegetables are very important in the well being of a society but the impact of GEC on these products has hardly been researched. Neither has the potential of indigenous fruits and vegetables, which might be used as alternatives been adequately studied.

The (urban) youth prefer processed food such as breakfast cereals to traditional fermented sorghum porridge. What will be the implications of shifts in productions zones on access to raw products for food processing industries and or availability of

infrastructure and supporting facilities in new production zones to process the required food items?

In brief, the region has a large suppressed demand for food, but food demand is also changing and less and less related to local comparative production advantages.

5.2Adaptations

5.2.1 Introduction

Development is a continuous process of adaptation of societies to a changing environment and opportunities. Global environmental change is not new, and therefore individuals and societies have been adapting to GEC, perhaps without realising that it is GEC. In addition, societies and individuals in semi-arid lands have accumulated experiences with phenomenon such as drought that may increase in frequency and intensity in future. It is important to understand and learn from relevant past adaptations and indigenous knowledge.

The purpose of adaptation within the GECAFS context is to assist policy makers in ensuring that disruption of food provision due to GEC is minimised at minimal costs, and where possible that food provision is enhanced. The key issues for adaptations are therefore to:

1. Identify and evaluate the possible adaptations mechanisms;
2. Identify, document and learn from past and current coping mechanisms employed by vulnerable groups in their day-to-day food supply systems;
3. Analyse and strengthen the capability of communities and countries to adapt as much as possible;
4. Identify the most suitable level at which each adaptation should be carried out (e.g. a regional or national grain reserve)

Adaptation constraints need to be resolved. For example, the lack of large capital investment may restrict adaptations in food production and distribution. Extra financial resources need to be made available to develop the necessary infrastructure and conduct agricultural research and innovations. Moreover, institutional and human resources/ skills represent a serious constraint to food provision in general but in particular agricultural revival and growth. Institutional capacity building and human resource development are critical in enhancing the adaptation capability of farmers and other stakeholders.

It is important that policy makers understand the commercial and/or livelihood strategies of food producers and those involved in food imports and distribution. Adaptations are usually based on perceived changes and occur within the strategies of the stakeholders. Therefore, it is required that stakeholders have appropriate and detailed information about changes, and as earlier chapters indicated this is still a problem for GEC, and clearly is an area to be addressed by a GECAFS Southern Africa project. Interviews and literature yielded three major issues:

- Monitoring and early warning systems (climate, local production, regional and global markets);

- Focused information on adaptation options available including research on alternative crops or livestock species;
- Vulnerability assessments (areas, groups);
- Dissemination of information-data. This area is critical to bring about timely response.

Powerful forces such as the introduction of the monetary system, urbanisation, breakdown of the extended family system, and adoption of western democratic institutions are transforming Southern African social security networks and increasingly constrain the past coping strategies. There is a need for research into new adjusted systems to fit into the current and future socio-economic systems. This requires that a GECAFS intervention in southern Africa documents and incorporates the major food production and distribution strategies at all levels starting from the household level.

Mehra (1995) has noted that adaptation to climate change in general should be closely linked to sustainable development and have a pragmatic plan to tackle poverty and gender inequalities at all levels.

Agricultural adaptations may involve changes in cultivated area, intensification and diversification (Boserup, 1989; Ellis, 2001). Interviews and literature yielded a variety of adaptations, mostly related to changes in cultivated area and agricultural practices.

5.2.2 Adaptation mechanisms for food production

In response to decreases in food production, farmers may expand dry land and livestock farming into un-used land. However, un-used land is often less suitable , and therefore expansion tends to have declining marginal returns. Adjustment of dry land practices may counter a decline in land productivity, for example by improved soil fertility and water catchment. Another adaptation is irrigation (cf. NEPAD), either through rehabilitation of collapsed schemes or through new schemes on suitable soils and with sufficient water (e.g. treated effluent).). Yet another adaptation are adjustments in farming practices to changed climatic and water resource conditions to sustain/ increase productivity, including use of fertiliser and pesticides. Changing crops is a third type of adaptation, either by switching to food crops that are more suitable to the new environmental conditions (e.g. from maize to millet, sorghum and cassave) or by growing cash crops, including veldproducts, that permit people to purchase food crops. Adopting new technology is another way of adapting to GEC. Examples include drought tolerant varieties, GMOs and better soil and water management techniques. Farmers can also adapt by engaging in mixed farming that reduces their risks and provides positive impacts on the different types of farming (e.g. organic manure, fodder, agro forestry, veldproducts, game ranching). Agricultural research needs to be directed towards conventional and non-conventional food and cash sources, which best suit local environmental conditions (e.g. sorghum and cassave) and are water efficient. Finally, extension and inputs services need to adapt to facilitate rapid change in production.

At the farmer's level, specific adaptation can be pursued as listed in Table 14.

Table 14 Examples of more specific adaptation strategies in food production

Sector	Possible Adaptation
Arable agriculture	1. Use of short season, drought resistance crop varieties and water efficient measures. 2. Use diversified production systems as opposed to monoculture 3. Irrigation: invest in water efficient irrigation technologies such as drip/trickle to reduce water losses through seepage and evapo-transpiration and consider timing of irrigation, crop water requirement, soil characteristic 4. Use conservative tillage, intercropping, crop rotation and other soil conservation methods to enhance long term sustainability of soils to increase infiltration capacity of soil, under-ground water recharge and reduce siltation and flooding 5. Improve early warning systems and crop forecasting technology and dissemination of timely information on the likely quality of the up coming growing season.
Livestock	1. Rearing different livestock breeds to reduce effect of drought, pests and diseases resulting from climate change (Hitchcock, 2002). 3. Recycling municipal waist water for production of fodder 4. Switch from livestock production to game farming or veld products based industry

5.2.3 Non-agricultural adaptations

From the perspective of food security, non-agricultural adaptations are equally important as agricultural ones. If people find income sources outside agriculture, they will be able to purchase food themselves. Currently employment outside agriculture is very limited in most southern African countries. However, ongoing work indicates a potential for income generation from ecotourism that are yet to be developed.

Another potential source of adaptation measure that most southern African countries have not yet developed is the Clean Development Mechanism (CDM). CDM is a project-based mechanism introduced in Article 12 of the Kyoto Protocol covering projects between industrialised and developing countries that result in the transfer of Certified Emission Reductions (CERs) from non-Annex I countries to Annex I countries (http://cdm.unfccc./). The purpose of the CDM is to assist Parties not included in Annex I in achieving sustainable development, in contributing to the ultimate objective of the Climate Change Convention and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments. Countries that participate in the CDM are required to establish a national authority for CDM that approves and co-ordinates all potential CDM projects and there should be a mechanism to verify and certify reductions of human-induced greenhouse gas emissions from projects. There is a potential for southern Africa countries to benefit from CDM given the ongoing bush encroachment and the likelihood for future climates to favour woody plants but there will be a need to monitor possible impacts of CDM on other land uses and the ecosystems in general.

Migration and seeking formal employment are the most common adaptation of people. While jobs are limited, many households have significantly reduced their dependency on agriculture, particularly in countries with growing economies (e.g. Botswana and South

Africa). At the country level, the pursuit of growth in non-agricultural employment and income opportunities/poverty alleviation and prudent and stable governance, including sound macro-economic management, appears to be the most promising adaptations.

5.2.4 Adaptations in food distribution

A key adaptation is the review and adjustment of their grain reserve to ensure that they remain adequate and efficient. The storage capacity needs to reflect the predicted changes in food belts. The combination of physical reserves and funds to purchase food are usually the least expensive solution.

Similarly, the adequacy and specifications of the transport (port, road and railway) and distribution networks need to be reviewed and adjusted to efficiently direct food from surplus to shortage areas.

Drought relief and aid programmes remain a critical component of food provision at the moment despite its short-term nature and the risk of consumer dependency on food aid. Labour-for-food programmes could overcome some of the disadvantages of food donation.

Marketing skills can be used to influence consumers' preferences in favour of products that can be locally produced and/or improve the quality of products with locally produced grains. This adaptation is not widely used as yet, but may have considerable potential. For example, Botswana has developed a local sorghum market that encourages the production of sorghum instead of maize.

5.2.5 Economic access to food

Improved economic access to food can be pursued by several means. Firstly, price mechanisms and policies could be designed that serve the interest of producers (incentive to produce more food) and consumers (to facilitate access to food). Secondly, food aid can be delivered to those, who cannot afford to purchase it, preferably by food-for labour or other inputs programmes. Thirdly, regional specialisation in food production and regional trade would lower production costs and food prices, and therefore improve access. This important adaptation is as yet hardly pursued, but should gain momentum with trade liberalisation and policy shifts towards food security. Fourthly, economic growth will lead to income and employment generation, both of which will facilitate access to food. Finally, stability and governance supported by an effective pool of human and institutional resources facilitate the establishment and maintenance of food provision systems

5.2.6 The spatial level of adaptation

Successful and efficient adaptations require appropriate adaptations at the local, national and regional level, and close interactions and coordination between the three levels.

Several adaptations are most efficiently done at the regional level. These include:

- Specialisation in food production and food trade. Some countries (Botswana and Namibia) have implicitly adopted a food production specialisation strategy through the food security and pricing policies;
- Grain Reserve and Food Fund. Issues include the balance between physical and financial reserves, control over the reserves and funds as well as the balance between national and regional reserves;
- Development and maintenance of infrastructure to reduce transport costs and food delivery time. This could be done through the corridor approach of SADC;
- Agricultural research, technology development and early warning/ monitoring

6 Possible environmental and socio-economic consequences of adaptation to GEC.

The socio-economic and environmental feedback will depend on the adaptations that are implemented. Since there is a limitation of information at the moment on how might climate change impacts manifest themselves at different scales, for instance within basins or regions of similar soil types and countries, it is difficult to determine with reasonable detail the types of adaptation measures that will be adopted from which likely feedbacks might emerge.

The possible environmental impacts of adaptations include:

- Changes in biodiversity due to GMO and extending the agricultural frontier;
- Agricultural pollution associated with use of fertiliser and pesticides;
- Water logging and salination due to irrigation;
- Land degradation due to agricultural pressure and use of less suitable land;
- Increase water scarcity due to irrigation.

The socio-economic impacts are difficult to predict, but issues raised during interviews and in the literature include:

- Extra costs of agricultural production due to GEC; Tyson et al (2002) argue that the commercial agricultural sector will be able to adapt to GEC, but at substantial costs, which may affect their competitiveness. Extra costs in the subsistence sector would aggravate poverty and endanger livelihoods and food security;
- Changes in consumer patterns and loss of economic access for those engaged in food production/processing due to increased reliance on food imports or shifts in production zones;
- Extra costs of food imports, which will depend among others on availability of surplus areas and the impact of GEC on global food prices;
- Mobilisation of international funds for mitigation/ adaptation measures. While the region's contribution to GEC has been very small, the predicted impacts are significant, offering an argument for international compensation;
- Future of food aid. Current food aid represent a substantial economic value, and it cannot be assumed to be available forever; Increased food aid has long term consequence of self-reliance even where labour-for food approach is used;
- Over-exploitation of resources, for instance veld products or underground water resources as food demand rises;
- A rise in demand for basic services such as schools, health, reticulated water facilities, and health problems due to rapid urbanisation;
- Loss of cultural identity, social fabric and or morals due to urbanisation leading to break down of family, commercialisation of sacred/divine areas under cultural tourism for instance or loss of culturally important economic activities such as cattle rearing; and

- Intense competition for resources in favoured regions in response to developed intra-regional trade - this may not favour the vulnerable groups such as women.

7 Conclusions and outline of possible GECAFS activities in Southern Africa

This section intends to bring together the main findings of this consultancy, and to outline possible objectives, targets and scope of a GECAFS intervention in southern Africa. A southern African GECAFS project should only be started if it adds value to existing research and policy efforts. The foregoing has shown clearly that GECAFS could add value to southern African agricultural endeavours, and is therefore justified.

Since the 1970s, African agriculture has been unable to keep pace with population growth and demand, and it has been unable to significantly boost economic growth. A wide range of human and some natural factors are responsible for this state of affairs (Table 11). The agricultural sector, which has a dualistic nature, is in a state of transformation, . It comprises of a small (in terms of farmers) commercial sector and a large (in terms of farmers) subsistence sector. Both sub-sectors experience serious – though very different- problems affecting production and food provision. Africa's share in world exports has declined, food aid to Africa has increased and investment in agricultural research and infrastructure decreased.

SADC and NEPAD plans exist for agricultural revival and growth through an increase in land put to agricultural production, better agricultural practices, and irrigation. Priority areas include sustainable land management and water control, improved rural infrastructure and trade, increasing food production and reducing hunger, and enhanced and coordinated agricultural research and technology. Donors are offering support, particularly when it benefits small farmers' livelihoods and contributes to the transformation from subsistence to commercial agriculture.

While many initiatives aim to boost African agriculture, few if any pay attention to GEC. This is understandable because of the many food emergencies that require immediate responses and results and because of the many uncertainties about the forms that GEC may take in southern Africa and implications thereof. It is problematic because GEC may render current revival efforts obsolete or uneconomic. Full incorporation of GEC in agricultural research and planning may generate substantial benefits in future. Moreover, given the current low agricultural productivity, the impacts of GEC may not lead to further production decreases, provided current agricultural constraints are successfully addressed.

Objectives of a GECAFS intervention in southern Africa could therefore be:

1. Document and disseminate the types of GEC expected in southern Africa;
2. Document and disseminate the consequences of expected GEC for food production, distribution and provision;
3. Select and implement GEC adaptation strategies towards food security in the short- to medium-term; and
4. Promote timely adaptations to negative and positive GEC impacts with minimal negative environmental and socio-economic consequences.

The Vision for southern Africa, without even taking into account GEC, is to promote improved food production and distribution in al all out effort to reduce and even eradicate

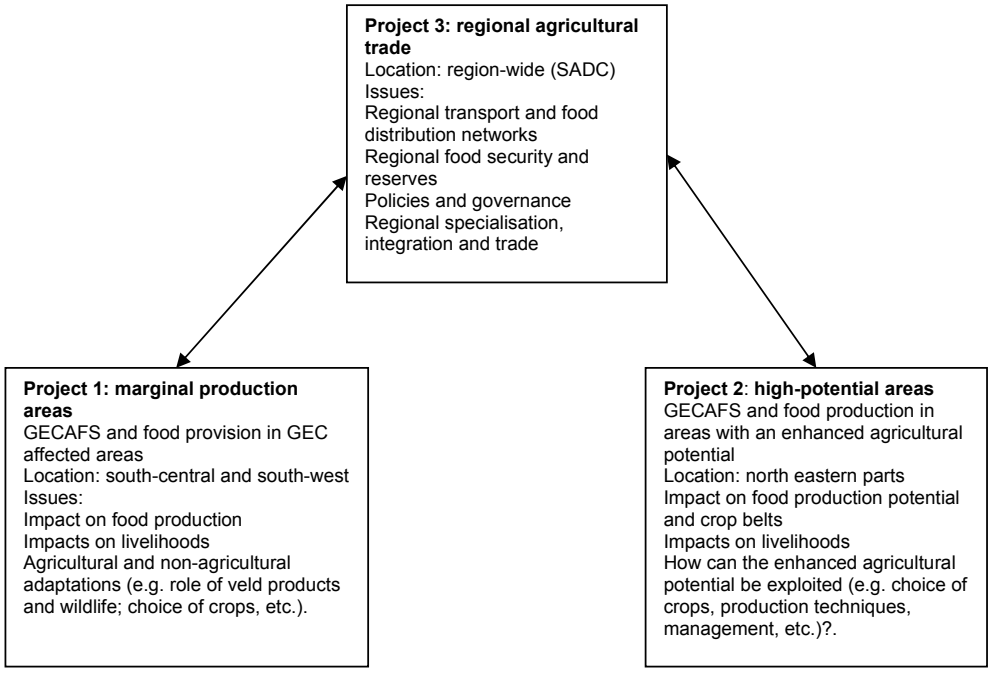
hunger and poverty. The Vision is to achieve self-sufficiency in food production of most basic grains and meat at the regional level, and to achieve food security at the national level based on specialisation in food production and agricultural trade. To realise this Vision in a holistic manner, whilst ensuring minimal environmental degradation, GEC needs to be factored into agricultural research and planning.

As currently food grains offer the largest challenge for policy makers, and GEC is expected to alter comparative advantages, it seems appropriate that GECAFS concentrates on the provision of food grains in southern Africa. As maize is the most important staple and is expected to be most affected by GEC, a GECAFS project should deal with maize production and trade. Marginal areas may lose their capability to grow food, and in that event growing cash crops and veld products could be most important for food provision. This is expected to occur in affected parts of Namibia, Botswana, South Africa and possibly Zimbabwe.

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.

It is proposed that GECAFS develops two projects in southern Africa, which are interlinked through food distribution and trade. The first project would be located in southwest/central Africa in areas whose production potential is adversely affected by GEC. Research issues would include: GEC impacts on food production and livelihoods, shifts in crop and animal production belts, etc. The second project would be located in north-eastern parts of southern Africa, where the production potential is expected to increase. The research issues would include the expected impact on food production, livelihoods and crop choice, and the potential to exploit the new advantages. The projects would be linked by transport, trade and policy issues, including regional integration and specialisation. Obviously, it will be necessary to develop specific research and policy questions for each project and for the trade part. Such a cluster of integrated projects covering such a wide terrain is new in the region, and would fit into GECAFS.

The ideas of the team are graphically outlined in the diagram below.



Various specific topics were identified for the three themes of GECAFS, and they are repeated here. Southern African GECAFS issues for theme 1 include the following:

1. Integrating long-term GEC concerns and impacts in the short-term struggle to improve food production, distribution and provision;
2. Detailed assessment of GEC on the major food products of the region;
3. Detailed assessment of expected GEC impacts on the transport and food distribution infrastructure;
4. Establishing an inventory of traditional knowledge on past GEC and vulnerabilities experienced then;
5. Vulnerability assessment to future GEC: identification of the vulnerable areas, groups and products (crops and animals);
6. Shifts in production belts/ comparative advantages of major crops (e.g. cassava/ sorghum) and animals (small stock-cattle);
7. Potential for new income-generating products (non-conventional crops and game);
8. Changes in water availability (also bearing in mind growing competition for water) and requirements;
9. Identification of the areas with enhanced potential due to GEC, and ensuring that this potential is exploited to the benefit of intra-regional trade.

In terms of vulnerability and adaptation (theme 2), the following issues appear to be important:

1. monitoring and early warning mechanisms;
2. vulnerability assessments (areas and groups);
3. access to information about GEC and possible impacts;

The typical adaptation issues include expansion of agricultural land, intensification through adjustment of farming practices and irrigation, changing crops and agricultural research and innovations. However, the best adaptations may be found outside the agricultural sector, e.g. by accessing formal employment and income opportunities. To understand adaptations, GECAFS projects should understand the livelihood and macroeconomic context, in which farmers and governments decide upon adaptations. Changes in food production and consumption patterns need to be matched by changes in distribution mechanisms, including grain reserves and storage capacity. Economic accessibility is expected to become an even more important issue than it already is, as the vulnerable groups have a poor adaptive capacity and tend to become poorer. Once more, non-agricultural development and poverty reduction strategies need to be integrated into GECAFS efforts.

Four types of adaptations would be most efficiently carried out at the regional (and national) level:

- Specialisation in food production and food trade;
- Grain Reserve and Food Fund;
- Development and maintenance of infrastructure to reduce transport costs and food delivery time; and
- Agricultural research, technology development and early warning/ monitoring.

Regional efforts require political commitment from most countries to design and implement the efforts.

The possible feedback impacts of socio-economic and environmental adaptations are briefly summarised in section 6, and not repeated here.

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Annex A: The Consultative Group on International Agricultural Research (CGIAR)

Keys to mass poverty alleviation

Eicher, (2003), observes that:

> "It is encouraging that many donors are now reordering their priorities and coming around to the conclusion that rural social services, food aid and post conflict aid may keep people alive but they do not increase **crop yields** and **earnings capacity** – the keys to mass poverty alleviation. … Without questions, donors should increase their investments in the prime movers (human capital, technology and institutional innovations) to increase farm production and accelerate agricultural growth. NEPAD should focus on mobilizing African and donor investment in genetic and agronomic research of Africa's eight major food staples because reducing food prices is the most promising avenue for reducing mass poverty in Africa"

Deriving from the above, and within GECAFS' context with particular regard to biophysical factors of production, efforts to reduce poverty in southern Africa should address crop yields, enhanced technological and institutional innovations and continued agricultural research. One of GECAFS' collaborating partners, the Consultative Group on International Agricultural Research (CGIAR), through its food and environmental organisations including the International Maize and Wheat Improvement Centre (CIMMYT) and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), has been engaged in genetic and agronomic research in Africa thereby adding value to these and other biophysical factors.

CIMMYT works with agricultural research institutions worldwide to improve the productivity, profitability, and sustainability of maize and wheat systems for poor farmers in developing countries. Similarly, ICRISAT's mission is to conduct research, which can lead to enhanced sustainable production of six drought resistant / tolerant crops, namely, sorghum, pearl millet, finger millet, chickpea, pigeon pea, and groundnuts; and to improved management of the limited natural resources of the Semi-arid tropical countries.

Whilst ICRISAT has been primarily a sorghum and millet research and training centre, (funded by USAID which funding has now dried up and therefore the project has effectively ended), it also participates in a number of other regional projects including:

- Risk Management by small-holder farmers through e.g. linking farmers to markets
- Soil Fertility Management Programme;
- Impact assessments (HIV/AIDS and Disease Control); and
- Desertification and Poverty.

The impact of these programmes is essentially to provide the means, in the form of appropriate genetic and technological innovations through research and the production of high-yielding and drought tolerant crops, to encourage maximisation of comparative advantage in food production and therefore food provision. These programmes are therefore aimed at appropriate resource utilisation in such a manner that the impact of human activity on the environment is minimised.

In order to address the impact of human activity on the environment, faced with GEC, it is necessary that attention be given to some of the baseline potential causes of such human behaviour. One such factor are the risks that the farmer faces against which he takes certain decisions in his cropping and livestock management strategies. Farmer risk management is one crucial element that needs attention and GECAFS, through its collaborating partners, can add value. The following section is an exploration of some of the farmer risks and therefore the potential linkages to GECAFS.

Farmer's risks and linkages to GECAFS

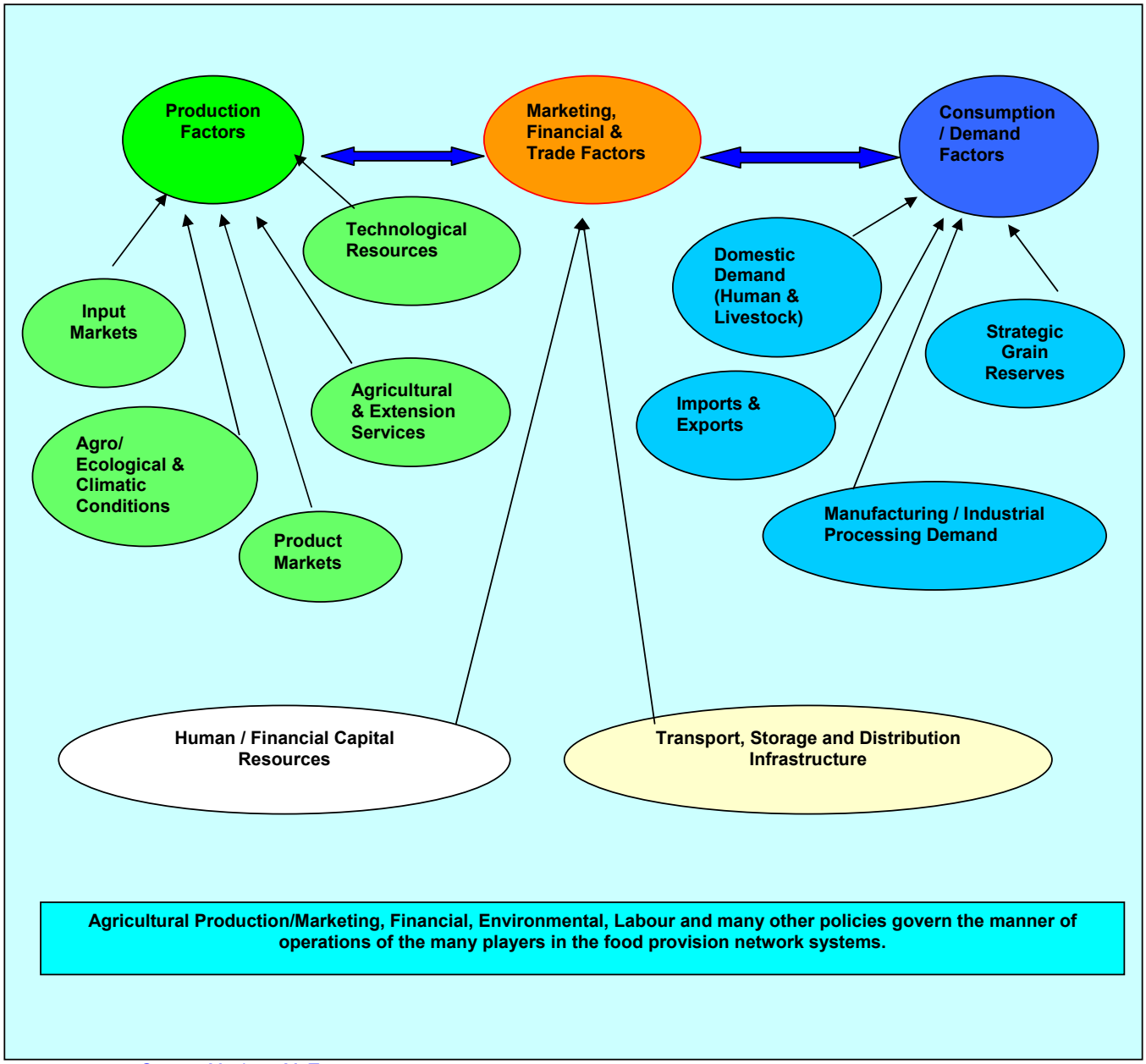
Key stakeholders
The key stakeholders in food provision in Southern Africa, like in any other part of the world, can be split roughly into three broad categories, namely **Production Stakeholders, Marketing/Financial &Trade Services Stakeholders, and Consumption / Demand Stakeholders**. It is acknowledged that there are interlinkages among these stakeholders but for purposes of this analysis, it is essential to attempt to fit each into a particular box. **Diagram 1** makes an attempt at breaking down who these stakeholders are by category.

Farmer Risks
The biggest challenge to food provision and therefore food security are farmer decisions, which are driven by the amount of information that the farmer has and the farmer's ability to respond to such impulses. Generally, farmers are very risk averse and therefore their decisions may not be in line with overall and broader desired national objectives. It is therefore extremely important that the farmer be provided with timely, accurate, relevant and quality information for optimal farmer decisions in relation to production strategies.

What are the risks that the farmer faces that need to be addressed so that the farmer can make the "right" decisions that will enhance his means of production and boost his desires to produce food for himself and the nation at large at minimal damage to the environment? **Diagram 2** is an exploration of the farmer's risks and the possible linkages through which GECAFS could add value.

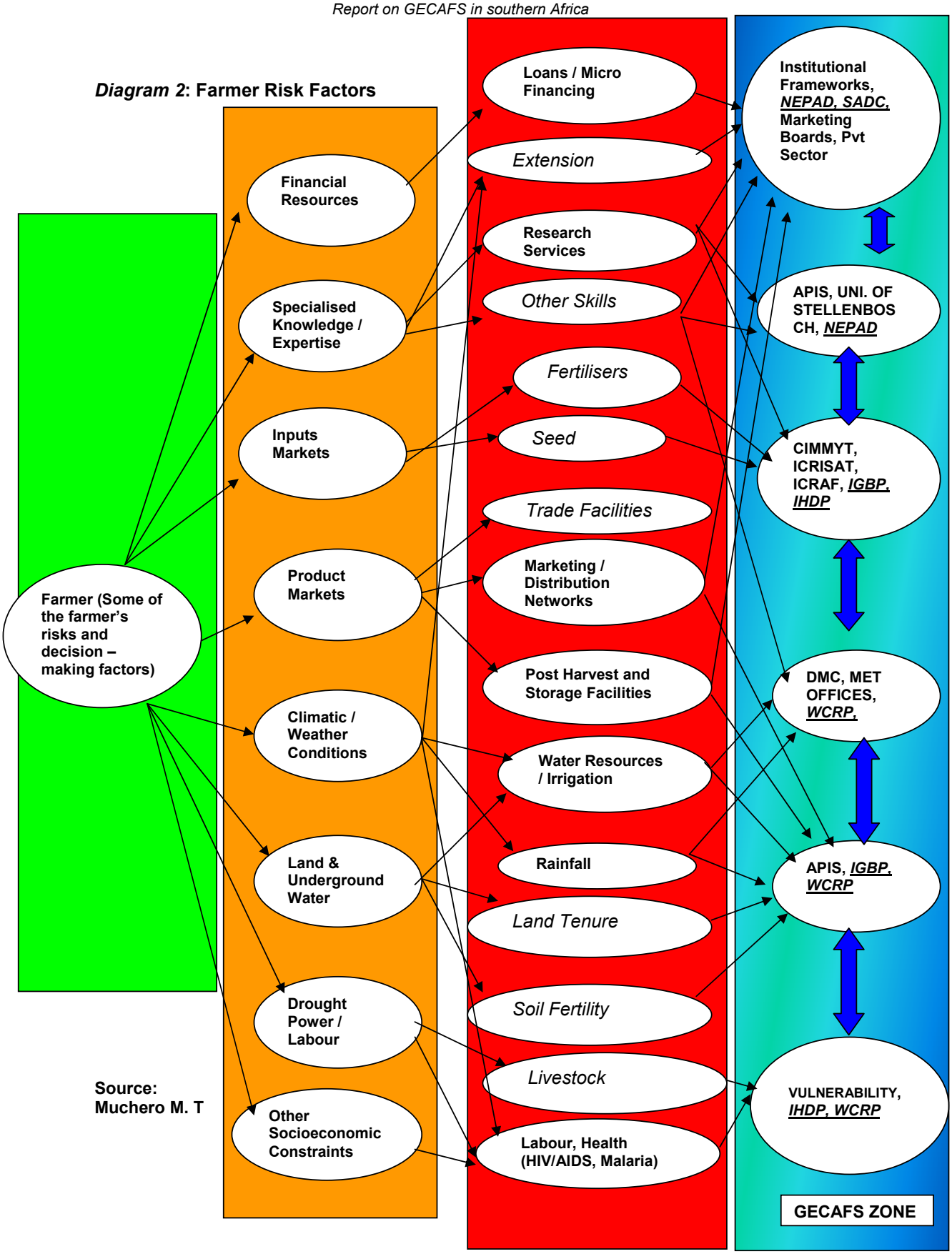
Shown in the fourth column of **Diagram 2**, the "**GECAFS ZONE"**, are the interlinkages and therefore possible science themes that GECAFS can exploit with the expertise from its relevant cooperating and collaborating partners in relation to farmer risk reduction strategies for Southern Africa. Also shown in that column are some of the findings during interviews in the form of potential projects or programmes that GECAFS could utilise as vehicles through which its efforts can be made present.

Diagram 3: Key stakeholders in the food provision system



Source: Muchero M. T.

***Diagram 2*: Farmer Risk Factors**



Source:
Muchero M. T

Risk aversion strategies

Stilwell (2000) writes:

> "It is noted that numerous local, regional and international studies have offered prescriptions on what should be done about land reform, rural credit, research, extension and training, agricultural markets, input supplies, and much more. However, there is a dearth of strategies and practical operational direction for how, by whom and with what resources these policy prescriptions are actually to be delivered. A coordinated effort should be made to set out the broad thrust of strategic actions that have to be taken to get rural delivery going and provide operational options for the delivery of rural development".

In an effort to achieve food security, it is essential, therefore, that more emphasis be placed on practical operable strategies and actions aimed at farmer**-risk reduction**. This implies that the farmer has to be afforded the information, the means, and the skills to perform his farming operations at optimal levels. GECAFS could contribute significantly towards certain of these issues as illustrated in Diagram 2. What needs to be done is to identify specific projects, which GECAFS can effectively contribute to.

The next challenge, therefore, is how to get this information and appropriate technology to the farmers when faced with the situation that extension services seem only able to reach out to about 40% of the farming population out of which only 10% are able to utilise this information or have the capacity to buy and implement appropriate technology?

Proactive regional risk management initiatives are therefore required and these will require institutional reforms or institutional development. Understanding how the farmer makes decisions is the important shift in paradigm that is required in order to achieve food security.

The ICRISAT Soil Fertility Management in Zimbabwe: New Approaches for Drought Prone Areas project aims to develop and disseminate practical methods to improve soil fertility on smallholder farms (Rusike & Heinrich, 2001). The approach involves:

- ✓ Farmer-participatory on-farm research, supported by simulation modeling and other strategic research;
- ✓ Farmer field schools and other alternatives for dissemination; and
- ✓ Strengthening input and output markets to increase farmer's incentives to invest in new technology.

Linking farmers to markets

It was noted in the interviews that if the region is to achieve food security, then it is paramount that the farmers be linked to markets (inputs and product markets) as this gives the farmer the incentive to produce. In order to achieve such linkages to markets, it is imperative that farmers be afforded good access to technical as well as market information in the form of options rather than specific recommendations for farmers to adopt. There is therefore the need for capacity building for purposes of assisting the farmer make appropriate decisions that will ensure food security.

To this effect, the following issues are critical towards improving food security in the region:

a) Access to Information;

b) Agricultural Incentives;
c) Marketing Infrastructure; and
d) Institutional Reforms.

Information flows and research collaboration
Information flows to participating players in agriculture are very poor in Southern Africa. From the interviews undertaken, it was gleaned that SADC had a lot of research emanating from SADC country offices. There is now very low agricultural research taking place in the southern African region, compared to the Central and West African regions, due to the depletion of competent human resources (scientists and researchers) in the region leading to very poor levels of research/understanding of research issues in the region.

There has also been very little support on research by governments in the region due to economic distresses, depleted human resources within governments themselves. As such, the region is now heavily dependent on international research assistance. There is need, therefore, in the area of agricultural research, for high competence levels of manpower to carryout research, interpret the results for use by farmers/interested stakeholders for the purpose of ensuring food production through reduced farmer risks and for increased levels of collaboration.

GECAFS' role

In summary therefore, effective high-risk management systems and policies are needed in the region. These include:

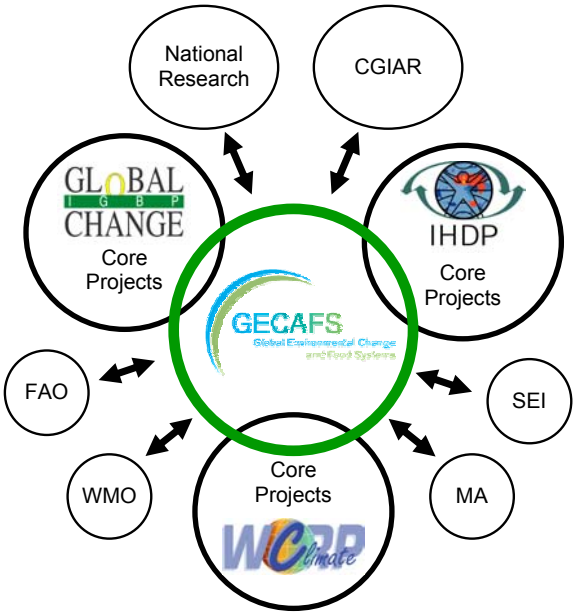
- Linking farmers to markets and improving on agricultural incentives;
- Regionalisation and harmonisation of agricultural and trade policies and practices in the region;
- Capacity building and improved vertical integration of information transfers and interpretations / application.

There is, however, a more critical need for the conversion of policy into implementable and influential factors that will help the farmer make better farming decisions that are in line with overall country and regional food security.

Drawing from GECAFS' broad base of expertise (see Diagram 3), GECAFS is poised to offer meaningfully to Southern African food security in the three areas; namely:

1. Farmer risk reduction and minimisation in production strategies;
2. Provision of "software" (information and researchable materials), through, for example, the Agricultural Potential and Trade Information System (APIS), for the development of larger agricultural production capacities (intensive agricultural production systems) coupled with corresponding agro-processing systems that can help ensure all-year-round supply of the desired tradable commodities whilst ensuring minimal damage to the environment. Effectively there is need to take full advantage of comparative advantage in food production in the region; and
3. Assist with socioeconomic factors such as vulnerability from various points of view including issues affecting Health (HIV/AIDS, Malaria, tuberculosis, etc) and general livelihoods.

Diagram: 3: **Relationship with ESSP Core Projects and examples of other collaborations**



Source: GECAFS International Project Office