Climate change and agriculture: Agricultural trade, markets and investment

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4

Background and Acknowledgements

Over the last few years, our understanding and certainty about how the climate is changing and the possible impacts this could have has grown hugely. In response there are increasing efforts to 'mainstream' what we know about these impacts into development policy and planning processes. Given the fundamental links between agriculture and poverty reduction and agriculture's dependence on the climate, understanding in more detail about linkages between agricultural policies and climate change is important and urgent.

This paper is one of a series of five outputs produced under a small project for the Renewable Natural Resources and Agriculture Team of the UK Department for International Development (DFID). The objective of the project was to identify the implications of climate change for key areas of DFID's Agricultural Policy and the Renewable Natural Resources and Agriculture (RNRA) Team portfolio and to produce a series of practical outputs to assist the RNRA team in programme implementation and communication.

The five papers are as follows:

1. A rough guide to climate change and agriculture
2. Climate change: Implications for DFID's Agricultural policy
3. Climate change, agricultural growth and poverty reduction
4. Climate change and agriculture: Agricultural trade, markets and investment
5. Access to assets: Implications of climate change for land and water policies and management

The papers are written by a team of researchers from ODI's Rural Policy and Governance and International Economic Development Groups. The authors are grateful to DFID for their funding of this project. The arguments presented in the papers are those of the authors and do not necessarily reflect the policy position of DFID.

Table of Contents

Tables

Abbreviations

BLS	Basic Linked System
CDM	Clean Development Mechanism
CO_2	Carbon dioxide

EU	European Union
FAO	Food and Agricultural Organization of the United Nations
FFV	Fresh fruit and vegetables
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse gas emissions
IIASA	International Institute of Applied Systems Analysis
LDCF	Least Developed Countries Fund
NAPA	National Adaptation Programmes of Action
ODA	Official development assistance
PRSs	Poverty Reduction Strategies
PRSP	Poverty Reduction Strategies Papers
RNRA	DFIDs Renewable and Natural Resources Team
SCCF	Special Climate Change Fund
SPS	Sanitary and phyto-sanitary
SRES	Special Report on Emissions Scenarios
UNFCCC	UN Framework Convention on Climate Change

> *Agricultural production, including access to food, in many African countries and regions is projected to be severely compromised by climate variability and change. The area suitable for agriculture, the length of growing seasons and yield potential, particularly along the margins of semi-arid and arid areas, are expected to decrease. This would further adversely affect food security and exacerbate malnutrition in the continent. In some countries, yields from rain-fed agriculture could be reduced by up to 50% by 2020.*
>
> *(IPCC, 2007)*

1. Introduction

Agriculture has received considerable attention recently with regard to climate change because of the high dependence of agriculture on the climate. Dependence on agriculture, especially in developing countries, also means that agriculture has an important role to play in debates about adaptation to climate change. Most studies and models on impacts of climate change on agricultural production indicate that there will be negative effects on crop yields over the next century. Some models predict that there will be an estimated 600 million additional people at risk of hunger if temperatures increase by 3° C (Warren et al., 2006), particularly in developing countries where people are already at risk.

On the other hand, models also predict that global cereal production will increase over the next century, even considering climate change, and appears to be sufficient to feed the projected world population of 9-15 billion in the year 2080 (Fischer et al., 2005). Global cereal production under different climate change scenarios, however, is projected to be highly uneven between regions, with temperate regions on the northern hemisphere benefiting from increased temperatures and longer growing periods for moderate degrees of warming, while tropical regions will loose agricultural production potential.

This implies that fewer people will have the possibility to feed themselves (even if this is desirable) and, hence, that there will be greater reliance on markets and trade. Currently, some developing countries are particularly vulnerable to additional impacts of climate change on their ability to attain food security, due to their unfavourable positioning in international trade, compounded by poor development of domestic and regional markets. Being able to balance growing differences between food demand and production will mean paying greater attention over the next two decades to develop policies supporting trade, and putting in place the necessary infrastructure and institutions.

The uncertainties with regard to climate change impacts on agriculture are considerable. Climate change impacts on international trade, markets and investments are even less clear. What can be anticipated is that climate change will affect the prices and volumes of goods traded between developed and developing countries, particularly agricultural raw materials and food, with wider macroeconomic consequences. Few studies so far have examined the effects of climate change on global trade patterns, but the consequences could be substantial, particularly for sea-borne trade and linked coastal manufacturing and refining activities (Stern, 2006).

This report is one of several outputs produced for DFIDs Renewable Natural Resources and Agriculture (RNRA) Team aiming at highlighting current knowledge and emerging themes related to climate change impacts on agriculture. It aims to support the RNRA Team in its assessment of the Agricultural Policy Paper with a view to address future climate change impacts on agriculture. The first output sets the scene by presenting current knowledge about the relationship between agriculture and climate change and outlines main areas of certainty. The second output directly assesses how well 'climate-proofed' the RNRA Agricultural Policy Paper is. The three other outputs relevant for DFID's Agricultural Policy focus in depth on the implications of climate change on (i) agricultural growth and poverty reduction, (ii) agricultural markets, trade and investments (this paper) and (iii) access to agricultural assets.

The report is structured as follows. Section 2 discusses aspects related to agricultural trade and markets for growth and poverty reduction. Section 3 outlines the main findings of climate change impacts on natural resources, agricultural production and food availability. Following from these findings, Section 4 discusses implications of climate change on agricultural trade and markets based on three scenarios and related policy implications. Section 5 asks what the implications of climate change on public investments and aid are and how the adaptation could be funded. Section 6 concludes with a number of policy recommendations.

2. Agricultural trade and markets for growth and poverty reduction

Very few countries aim for, or achieve, food self sufficiency; trade in food products is the norm. Hence, the supply of food within a country is a function of: the volumes produced domestically, the price of imports (which in turn depends on global demand and supply), and the price of the exports used to generate foreign exchange. Climate change could affect all three of these variables.

2.1 The types of effect

Detailed forecasts for the potential effects of climate change on food production in developing countries are given in Section 3. However, it is important to note that the outlook for domestic production in sub-Saharan Africa is generally considered to be poor. This implies a growing reliance on agricultural imports.

The **price of imports** can be affected both directly and indirectly by climate change. If increased production from the areas that will ‘benefit’ from climate change is smaller than the decline in those that will ‘lose’, global supply will fall and prices will rise. This direct impact would be additional to all of the others influences on global demand and supply (such as rising incomes and demand for meat in East Asia). It could also be affected indirectly by countries’ responses to climate change. If, for example, concern over climate change leads to a large increase in the production of biofuels, this could, in turn, raise prices even further by diverting agricultural resources away from food production.

Changes to a country’s **export prices** may reinforce or offset any change to prices of imports. There could be several – difficult to predict – indirect effects for non-agricultural exports. Will concern over climate change lead, for example, to a change in the pattern of manufacturing with increased use of some materials (with a lower carbon footprint) and declining use of others (with a higher one)? It would be easier to predict the potential changes affecting agricultural exports.

In cases where a country exports agricultural goods, the net impact of climate change will result from a combination of the impact on their production of exported crops and demand for these in the world. For example, if an exported crop/animal product is less susceptible to the adverse production effects of climate change in a particular country than those products destined for domestic consumption, the decline in domestically produced food supply may be offset by an increased ability to import (especially if world prices for the export crop also rise). By contrast, if the export crop is affected to the same (or a greater) extent than is domestic food production, the two adverse effects will reinforce each other.

Finally, as with imports, there is a range of potential indirect effects of climate change on exports that could result from the policy responses of different governments. Concern over ‘food miles’ could, for example, lead to a reduction in consumer demand (or the imposition of government controls) in export markets thus reducing the ability of developing countries to mitigate the adverse effects of climate change through trade.

2.2 Applying it to Africa

How might this complex set of influences affect Africa? The region as a whole has seen a growing dependence on imported food over the recent decades. It has seen particularly substantial relative growth in imports of cereals in general and wheat in particular (Rosegrant et al, 2001). With sub-Saharan Africa expected to continue its poor production performance relative to population growth, its net import requirements for cereals (mainly wheat but also rice and maize) are projected to double between 1997 and 2020 from 12.4 million tons to 29.5 million tons (Rosegrant, 2004), without taking into account any climate change impacts. Contrary to conventional wisdom, most of these imports have been paid for with foreign exchange and are not solely food aid.

Some countries (such as Nigeria) have generated the foreign exchange required to pay for the imports in ways that are unlikely to be adversely affected by climate change (i.e. in this case oil). In other cases (such as Zambian copper), it is conceivable that exports could be affected by the wider ramifications of climate change (e.g. as a result of changes in the use of materials) which are very hard to predict. One group of countries, though, is clearly affected by climate change on both the import and export front. This includes the states that generate significant foreign exchange through the export of agricultural products.

For many developing countries, especially in sub-Saharan Africa, exports of tropical primary agricultural commodities, including cocoa, coffee, cotton, sugar, tea, and tobacco have been – and will remain – an important source of income and, potentially, growth. They provide around half of sub-Saharan export earnings. However, the prospects for significant growth based on expanding exports of these products are limited by poor price prospects (Diao & Hazel, 2004).

As a reaction to declining terms of trade and high price volatility, a growing number of developing countries started to turn away from traditional, tropical, agricultural export commodities to non-traditional exports (e.g. fruits, vegetables, nuts, fish and shrimps and dairy products) (UN, 2002) in the hope of finding new sources of income for growth and development. In the case of sub-Saharan Africa, this has often meant a shift towards non-traditional horticultural crops because of comparative advantages, such as favourable climate all year round, all year round water availability, or cheap labour.

The non-traditional export sector offers prospects for significant growth. Imports of leguminous vegetables, for example, rose in the European market by more than 130% between 1989 and 1997, with almost 75% of the imports coming from sub-Saharan Africa. However, niche markets tend to be highly competitive and specialized, with rigorous quality standards set by importers or retailers in the North. It becomes increasingly difficult – and expensive – for smallholders to meet these standards, and there has been a shift to larger, often company-owned, farms. In addition, horticulture exports only account for a small share of total agricultural exports and agricultural GDP in most export countries (Diao & Hazell, 2004). There is also increasing competition as a number of countries are trying to repeat the success of early entrants, and demand is expected to grow slower in Europe resulting from limited population growth rates and already high levels of consumption (Singh, 2002).

One reason why growing cereal imports have proved to be financially viable for some countries is that the prices of their agricultural exports have risen faster. In both cases the prices concerned have been heavily affected by Northern agricultural protection and preferential trade policy. Prices of the cereals that Africa imports have tended to be depressed because of ‘surplus production’ in protected Northern markets. By contrast, favoured developing countries (including those in sub-Saharan Africa) have been able to export some commodities under preference at prices that are higher than would have been the case under a more liberal market regime. This ‘price premium’ has been particularly marked for sugar (exported by several sub-Saharan African states), and beef (exported by a few), but it has also existed for horticultural products (Kenya, Zambia and others), and some fruits (Namibia, Swaziland and others).

The balance of Northern agricultural production between different types of commodity is already undergoing a process of change as a result of domestic agricultural reform (including the changes to the EU’s common agricultural policy). It is still far from clear how these changes will affect the global supply of cereals. Climate change, by altering the feasibility of different types of agricultural crops/livestock products (in addition to altering the overall level of production) provides an additional complication in making such forecasts. If, for example, some cereal products are less vulnerable to adverse climate change than are, for example, dairy products, there might be a shift in the balance of European production that would offset to a limited degree declining yields for cereals induced by climate change. Alternatively, the opposite could happen!

A particular concern for Africa must be that its ability to fund increased imports through agricultural exports will be undermined by the ‘collateral damage’ of Northern responses to climate change. A particular concern is over ‘food miles’, related to climate change impacts of trade of high-value fresh produce which, to a large extent, is air-freighted. The debate is especially acute in the UK, where daily fresh fruit and vegetables (FFV) worth over £1 million in retail value is consumed (MacGregor & Vorley, 2006). Whereas it is difficult to argue that developing countries should be somehow ‘exempt’ from legitimate actions designed to curb climate change, the evidence is overwhelmingly that the ‘environmental costs’ of transporting agricultural products from developing countries to Northern markets is trivial compared to those involved in domestic transport within those markets. There is increasing evidence that the UK’s carbon footprint[1] is largely domestically generated. Additionally, increased flights appear to be mainly passenger traffic, with passenger flights accounting for 90% of all emissions from air transport. Air-freight of FFV from sub-Saharan Africa accounts for less than 0.1% of total UK carbon emission, and are, compared with UK domestic food-miles, negligible (MacGregor & Vorley, 2006).

There is evidence that for some products (e.g. cut flowers), energy consumption can be lower for air-freighted imports from sub-Saharan Africa than for regionally or locally produced flowers from EU hothouses. In the case of sea transport, research has shown that sea transportation of New Zealand lamb uses less energy than that used during the transportation of lamb produced regionally in Germany, and beneficial climatic conditions in New Zealand were found to result in less energy use than German operations. Due to developments in shipping technology, some fresh produce, such as asparagus from Latin America, previously only flown can now be shipped, saving about 56 MJ/kg produce (Wangler, 2006).

Action against ‘food miles’ (whether legitimised by government or simply a result of consumer action) risks dealing with a trivial element of the problem to the neglect of the major elements and at the expense of countries that can least afford it. The problem with the

[1] According to the UNDP Human Development Index, the carbon footprint (expressed as carbon dioxide emissions, in t/capita) in 2003 was global: 4.7, OECD: 9.6, UK: 9.4, sub-Saharan Africa: 0.7, Kenya: 0.3.

food mile debate is that it is socially and economically blind. There is also a tendency that it is mis-used in a protectionist way by northern advocacy organisations. It does not consider the huge benefits the production and export of FFV provides directly and indirectly to several poor sub-Saharan African countries – and millions of poor people.

Kenyan horticulture exports, despite growing competition from other sub-Saharan countries (mainly Zimbabwe, South Africa, Cameroon, Cote d'Ivoire, and increasingly Ethiopia for flowers) have grown at over 6% p.a. for the past 30 years, reached 13.6% of export revenues in 2003 (International Trade Centre), and is one of the top four foreign exchange earning industries (McCulloch & Ota, 2002). The horticultural export industry is providing jobs to about 2 million people in Kenya as workers in packhouses, on exporter's own and large farms, and as smallholders. A study on the income and poverty reduction effects of the Kenyan horticultural sector showed that average incomes of both urban and rural people employed in the sector were higher than those not having any income from the sector (McCulloch & Ota, 2002).

One solution could be to shift commercial advantage from goods requiring air freight (such as horticulture) to those amenable to sea freight (such as pineapples, sugar, or processed foods like chocolate). This would tend, in turn, to have implications for the structure of production. Smallholders can participate in horticultural exports (even though it is tough) because individual consignments can be small. Sea freighting of fresh products tends to require large volumes of identical items (so that they ripen uniformly whilst en route) and so favours large producers.

The trade-induced poverty effects of climate change will thus be a combination of changes that:

- alter the *total supply* of food within a country (from the combined effects of changes to domestic supply, to the volume of exports and to the relative price of imports and exports);
- alter the *balance of production* between individuals who are currently net producers and those that are net consumers, between those that produce goods for the domestic market and for export, and between those who source their consumption domestically or from imports;
- alter the *structure of production* between small and large farmers and between landed and landless labour.

Given this complexity (and the great uncertainty over the path of climate change – see next section) the most useful response is to construct a set of stylised scenarios. This is done in section 4. Between them they illustrate the range of possible impacts on poverty.

3. Impacts of climate change on agricultural production, consumption and trade

Climate change impacts on agricultural production and trade are normally investigated by linking climate change models with agricultural trade models such as the 'Basic Linked System' (BLS) developed FAO and the International Institute of Applied Systems Analysis (IIASA). The BLS is usually run using the Special Report on Emissions Scenarios (SRES) developed by the Intergovernmental Panel on Climate Change (IPCC) (IPCC 2000) 'without' and 'with' climate change factored in to separate out the impacts of climate change variables from other in the scenarios.

The companion paper 1 to this project – "A rough guide to climate change and agriculture" (Peskett, 2007) – discusses the main IPCC scenarios and how they might impact on agricultural production, and highlights a number of other issues such as impacts of climate change on livestock, on soil degradation, and on water availability, which are not covered by the scenarios themselves.

Summarising modelling findings relevant for global crop production and trade shows the following:

Table 3.1: IPCC SRES Scenario's impacts on cereal yields, cereal imports and undernourished people

	IPCC SRES Scenario			
	A1F1	A2	B1	B2
Population in 2100 (a)	7 billion	15 billion	7 billion	10 billion
Economic growth (a)	3.5% p.a.	2% p.a.	2.75% p.a.	2% p.a.
Emission levels (a)	High	Medium high	Low	Medium low
Temperature increases (°C) (a)	2020: 0.7 2050: 1.96 2080: 3.67	2020: 0.59 2050: 1.59 2080: 2.9	2020: 0.54 2050:1.15 2080: 1.76	2020: 0.61 2050: 1.31 2080: 2.08
Cereal yields (without beneficial CO_2 effects (b)	decreases 10 to 18% by 2050, up to 30% by 2080 in Africa and parts of Asia	similar to A1F1 largest contrast between developing and developed countries		
Cereal imports in developing countries in 2080 (c)		430 million t	170 million t	
Number of people at risk of hunger in 2080 with and without CO_2 fertilisation (million) (c)	136 370	742 - 885 950 - 1320	99 – 102 125	221 – 244 257 - 384

(*Sources*: (a) Stern, 2006; (b) Parry et al., 2004; (c) IPCC 2007)

3.1 Impacts of climate change on agricultural resources

Modelling of environmental constraints for agriculture shows that under the current climate about two-thirds of the global land surface – some 8.9 billion hectares – suffers severe constraints for crop cultivation: 13.2% is too cold, 26.5% is too dry, 4.6% is too steep, 2.0% is too wet, and 19.8% has poor soils. Under climate change and by 2080, regional analyses predict an expansion of land with severe constraints. For southern Africa, these changes are particularly severe: an additional 11% of the total land area of 265 million hectares will be at risk of being severely constrained for crop cultivation (Fischer et al, 2005).

Considering climate change scenarios, agricultural land suitable for cereal crop cultivation will expand significantly in North America (40% increase over the 360 million ha), northern Europe (16% increase over current 45 million ha), the Russian Federation (64% increase over current 245 million ha), and East Asia (10% increase over current 150 million ha), due to longer planting periods and generally more favourable growing conditions under warming. Significant losses are by contrast predicted in northern and southern Africa, due to a worsening of growing conditions from increased heat and water stress (Fischer et al., 2005).

An A1F1 world will be far more challenging for arable-land farmers, beginning roughly in the middle of the century. Especially in Africa, CO_2 fertilisation effects will be unable to counter the projected 20% reduction in cereal yields (Parry et al, 2004). At country level, more mixed results emerge. A group of 40 countries worldwide will experience mean losses of 15% of their cereal-productivity potential. By 2080, the total population of the currently over 80 food-insecure countries is projected to increase to about 6.8 billion (up from currently 4.2 billion). The A1F1 to B1 scenarios indicate that 20-40 poor and food-insecure countries may loose on average 10-20% of their cereal-production potential under climate change. Simulations for sub-Saharan Africa predict that Sudan, Nigeria, Senegal, Mali, Burkina Faso, Somalia, Ethiopia, Zimbabwe, Chad, Sierra Leone, Angola, Mozambique and Niger would lose cereal-production potential by 2080 across all emission scenarios. The population of these countries currently is equivalent to 45% of the total undernourished population in sub-Saharan Africa. 10 countries, on the other hand (Zaire, Tanzania, Kenya, Uganda, Madagascar, Cote d'Ivoire, Benin, Togo, Ghana and Guinea), with 38% of the undernourished population of sub-Saharan Africa will gain cereal-production potential by 2080 (Fischer at al., 2005).

3.2 World food systems - linked food systems

While climate and farm management are key determinants of food production locally, agro-economics and world trade combine to shape regional productivity significantly. The BLS developed at IIASA comprises of a series of national and regional agricultural models, providing for analysis of world food systems, where national agricultural economies interact with each other through international trade.

Global cereal production

Current world cereal production is modelled at 1.8 billion metric tons (G ton). By 2080, BLS projects global cereal-production in the range of 3.7 G ton in scenario B2 and 4.8 G ton in scenario A2. For developing countries, increases are projected to range from 2.3 - 3.2 G ton – about a threefold increase in production from the 1990 baseline level (Fischer et al., 2005). Africa is to gain even more as a consequence of the substantial economic development assumed in the scenarios. This global production forecast, excluding regional surpluses and deficits or necessary adjustments through trade or food aid, appears to be sufficient to feed the world population of about 9 billion (15 billion in the A2 scenario) by 2080 (Fischer et al., 2005).

Prices and agricultural GDP

Price changes resulting from climate change impacts are modest and range between 2% and 20% in the short to medium term. Higher output associated with a moderate increase in global mean temperatures will likely result in a small decline in real world food (cereals) prices, while global mean temperature changes in the range of 5.5°C or more could lead to a pronounced increase in food prices (Easterling, 2007). Also, the impacts of climate change on agricultural GDP until 2080 are likely to be small at global level, and are estimated to range between -1.5 to +2.6%, depending on the scenario. Agricultural GDP in mid to high latitude countries would benefit under climate change, whereas BLS results indicate decreases in agricultural GDP in low latitude regions, with the exception of Latin America (Fischer et al., 2005).

Impacts on cereal trade

SRES simulations predict a growing dependence of developing countries on net cereal imports, totalling in 2080 between 170 million ton and 430 million ton, depending on scenario. The comparative advantage for producing cereals is predicted to shift towards developed countries, and net imports of developing countries increase by about 25%, i.e. between 90 and 110 million tons of additional cereal imports. OECD countries, on the other hand, are projected to remain major cereal exporters, with net exports in 2080 ranging from 240 million ton in scenario B1 to 380 million ton in scenario A2 (Fischer et al., 2005).

Food security

It is estimated that in 2080 about 768 million people (almost the same as in 1999, where the FAO estimated 776 million (FAO, 2003)) will be undernourished (Fischer et al., 2005). Regional differences between developed countries generally benefiting from climate change, and developing countries where crop production is projected to decline considerably are likely to grow stronger through time, leading to significant polarisation with a substantial increase in risk of hunger among the poorest countries (Parry et al., 2004), especially in sub-Saharan Africa and South Asia, where still a large portion of the population will depend on agriculture, and where capacities (e.g. technologies, finances, investments, etc.), both at national and farm level to adapt to climate change, are lowest.

4. Climate change implications for agricultural trade and markets

Despite improvements in data availability and models, there are a number of uncertainties with regard to climate change impacts on agricultural productivity, especially in developing countries, where data is even scarcer. There are, however, a number of issues where general agreement exist (Peskett, 2007):

- the only certainties about the impact of climate change on agriculture are increasing uncertainty and variability and an increase in frequency and severity of extreme events (storms, hurricanes, droughts, etc.);
- there are opportunities for some countries under all but the most extreme scenarios (e.g. North America, Russia, China), leading to an expansion of potential agricultural crop land;
- all scenarios show declining yields in Africa in the long run, but the level and rate of this decline differs among the scenarios, and that;
- these scenarios show relatively similar impacts on agriculture in the next 1-2 decades and predict impacts to be moderate during this period at global and regional scales. Impacts at smaller scales (intra-regional and within countries) may be much more severe but they are much harder to predict.

Globally, cereal production worldwide is predicted to increase from currently 1.8 G ton to 3.7 – 4.8 G ton, depending on the socio-economic scenarios applied. These projections represent a near doubling of current global production, in response to the projected rise in population and resulting demand and income. Land and crop resources, together with the technological progress, appear to be sufficient to feed the world population in 2080. Regionally, however, the results are more heterogeneous. Of particular relevance to regional food security is sub-Saharan Africa, where a growing share of undernourished people is located (Fischer et al., 2005).

Modelling results (Section 3) show an **increasing gap** in cereal production between developed and developing regions especially after 2020. Whereas semi-arid developing countries, notably in sub-Saharan Africa and in some areas in South Asia where suitable land resources are limited, will see reductions in production in the range of 5-10%, increases are projected for North America, Europe and the Russian Federation and parts of East Asia. It seems very likely therefore, that trade will form an increasingly important part of African attempts to maintain adequate food supplies. Naturally, aid donors will not – and should not – abandon support for staple food production in sub-Saharan Africa. However, they must assume that any success in raising yields and introducing climate change proofing of the agricultural sector will simply slow down rather than reverse the negative trends that are forecasted.

It is also likely that the ‘big picture’ forecasts simplify a much more differentiated pattern of reality, with some parts of Africa performing less badly than others. While Sudan, Nigeria, Senegal, Mali, Burkina Faso, Somalia, Ethiopia, Zimbabwe, Chad, Sierra Leone, Angola, Mozambique and Niger would lose cereal-production potential by 2080 across all emission scenarios, cereal production potential is projected to increase in Zaire, Tanzania, Kenya, Uganda, Madagascar, Cote d’Ivoire, Benin, Togo, Ghana and Guinea by 2080 (Fischer at al., 2005). So there could be an increase in intra-regional trade. Notably, at the level of aggregation of this paper and considering 'moderate' scenarios (not including extreme cases where production declines severely across the whole planet), there is no significant difference between an African country being dependent on imports of food from Europe or USA and on imports from a regional trade partner. In both cases, the salient point is that it is more dependant in future on trade than it is now.

4.1 Three Scenarios

Climate change is only one set of challenges that increases the vulnerability context in which agricultural activity takes place. Due to the uncertainties of climate change impacts on agriculture, and also of the socio-economic development paths in the North and the South and related policy responses, large uncertainties remain with respect to what impacts climate change might have on agricultural production and international trade.

Given the consensus among the forecasters about the overall production effects in sub-Saharan Africa, the three scenarios developed in this section focus on different trade outcomes. The focus on sub-Saharan Africa was chosen because projected negative climate change impacts on agricultural production are largest here and affect a considerable portion of the poor, who, also in future, will still be mainly rural (IFAD, 2001). Additionally, many sub-Saharan African countries depend for their foreign exchange heavily on exporting agricultural raw materials – which are assumed to also be affected by negative climate change impacts. For example, a warming of only 2°C would massively cut back the land area that is suitable for coffee in Uganda (GRID 2002). Similarly, cocoa production would suffer heavily resulting from climate change impacts, as cocoa is highly sensitive to changes in the climate – from the hours of sunshine, to rainfall, soil conditions and temperature. Climate change could also alter the development of pests and diseases and modify the host's resistance (Anim-Kwapong et al., 2005)

As explained in Section 2, the trade outcome will be a function of climate change's impact on total agricultural supply within a country, on the balance between output destined for export or for the domestic market, and on the structure of production. These differences are captured in the three scenarios set out in Table 2.

All of the scenarios relate primarily to countries that are agricultural exporters. As explained in Section 2, some African countries generate a large part of the foreign exchange required to fund imports through the export of non-agricultural goods (such as oil, minerals, diamonds, etc.) and will continue to do so. The effect of climate change for these countries will be to make more extreme the challenge that they already face today: how to enhance the value of exports and ensure that the gains are distributed in a poverty reducing way that benefits the rural sector.

Table 4.1: Scenarios for agricultural exporting sub-Saharan African states

Scenario	Total food supply	Distribution	Implications
1. Declining export agriculture	Sharp fall in both domestically produced and imported food	Share in consumption of urban/non-agricultural rises and share of rural falls	Severe rural poverty persists and leads to increased internal and external migration

2. Increased capital intensive agricultural exports	Less severe decline as imports hold up	Share in consumption of smallholders falls (and that of urban/non-agriculture is smaller than in scenario 1, albeit greater absolutely).	Impact on rural poor will depend on extent of labour demand in rural non-agricultural employment
3. Increased labour intensive agricultural exports	Same as scenario 2.	Rural share of consumption holds up well	Optimum poverty impact

Scenario 1
Under scenario 1, it is assumed that the impact of climate change on agriculture is all-encompassingly bad. Not only does production of domestic staples decline but so does production of the goods that are used to generate export revenue. This is the worst possible outcome for the rural sector.

There is a large fall in total food supply and the impact is biased against the rural sector. This arises because command over what imported food exists lies mainly with the urban and non-agricultural sectors. Rural areas are able to produce a smaller share of their total consumption and acquire a smaller share of anything that is imported than they are at the present time. The results are likely to be dramatic in terms of increased migration both domestically (to urban areas) and internationally (including to Europe).

Scenario 2
Under scenario 2, this worst case outcome is avoided because of investment (assumed to be largely from the private sector) in 'climate change-proof' agricultural production for export. This could include, for example, a concentration of production of horticultural products in climate controlled, low water using units, but it could also be via new cultivars of traditional agricultural export commodities.

Because imports of food are assumed to hold up, the fall in domestic food availability is smaller than under scenario 1 and consumption is not biased wholly against the rural sector. But, the proportion of the rural population that has command over imports is relatively small since production methods are assumed to be labour saving and capital intensive. Much of the rural population does not produce directly for export, nor does it work as labourers on the export-oriented farms.

The implications for rural-urban balance will depend, therefore, on the extent to which profits from capital-intensive, high-tech agriculture are spent in rural areas and generate non-agricultural employment and incomes. It must be assumed that there will be some such expenditure and, hence, severity of rural poverty and the extent of out-migration from the rural areas will be somewhat lower than under scenario 1. At the same time it would be optimistic to assume that with these investments in the rural sector poverty could be eliminated all together, and that there will be no such increase in migration.

Scenario 3
Scenario 3 provides the best case outcome. Not only do agricultural exports hold up (to a certain extent) but they are produced both by capital-intensive high-tech producers and by small holders / labour intensive producers. The rural economy can command a reasonable share of imported food and the impact on poverty reduction is the least unfavourable.

4.2 Policy implications

Many of the factors that will determine which scenario is played out are completely outside the control or influence of DFID (or OECD governments more generally). They relate to the technical characteristics of the agricultural goods than can be produced in particular countries and regions, as well as the domestic policies of the countries concerned. But it is possible to identify 'Northern policies' that would tend to facilitate a particular outcome or the reverse. Table 3 sketches illustrative examples of these.

Table 4.2: Policy implications of the three scenarios

Scenario	Policies making this outcome more likely	Policies making a better outcome more likely
1 – declining export agriculture	• Neglect of "climate change proof" technology for export agriculture; • Transport and related policies that discriminate against sub-Saharan African transport modes; • Subsidies to domestic producers; • Restrictions on global trade in biofuels.	• Early shift in emphasis for technical support from doomed crops to more climate change-proof ones; • Tackling the (large) domestic footprint of food consumption before the (small) external one; • Taxes on domestic use of climate change-adverse inputs (e.g. artificial fertilisers); • Removal of all import restrictions (and subsidies limited to domestic suppliers) of biofuels.
2 – increased capital-intensive (hi-tech) agricultural exports	• Failure of public provision of support for smallholders and labour-intensive, climate-change-proof production methods; • SPS and other regulations that are more difficult for smallholders to meet.	• Early and marked shift in public support to R&D, extension, market development, rural infrastructure and services so as to benefit directly smaller farmers able to produce for export.

Column 2 of the table flags examples of the sort of policies that are likely to make the outcome concerned more likely in the 'negative sense' of failing to support the achievement of a better outcome. Hence, for scenario 1, column 2 identifies Northern policies which would make this worst outcome more likely, whilst for scenario 2, it indicates those that would limit the likelihood of reaching the more desirable results of scenario 3. In the same spirit, column 3 shows the policies that would help to move up one level to the next best scenario. (Obviously, therefore, there is no need for a row on scenario 3: it is achieved by avoiding everything in column 2 and undertaking everything in column 3!).

The policies listed in Table 3 do not aim to be an exhaustive overview, but they provide a sensitisation guide to Northern policy makers. It takes some well understood policies in different key areas to demonstrate why they might result in one outcome rather than other. And it helps, therefore, to distinguish the roles of policies that are wholly within DFID's portfolio and those on which it can only offer advice.

Aid policies

Given the negative forecasts for staple food production in much of sub-Saharan Africa, the 'Northern response' most likely to result in this worst outcome would be to ignore the implications of these predictions for current efforts. If countries are becoming more dependent on trade for their food supply, it is axiomatic that an increasing emphasis must be placed on those economic actors able to produce a surplus of export quality. These people, however, are often not the poorest people in the poorest regions, and it is not food for domestic consumption that they produce. A combined effort would thus be needed to support those economic actors that can produce exportable products or are able to move into capital-intensive and high-tech agricultural production systems. At the same time, they should aim to ensure that those rural households that are unable – because of a range of factors – to adjust their mode of production and probably be hardest hit by climate change impacts, would be enabled to access sufficient food and other basic needs. This may be achieved through stepping up safety net programmes or social protection measures as a complement to the income they can gain from reduced agricultural activities. These actions should be accompanied by investments in the natural resource base (e.g. sustainable land management) and supported through investments in human and social capital to assist those farming households losing out as a result from climate change, to diversify into other sectors.

One of the assumptions behind scenario 2 is that it is the private sector that wakes up first and most extensively to the challenges of climate change and makes the necessary investment, both because it offers economic opportunities and as a way of safeguarding investments. This is not the worst scenario – but nor is it the best from a poverty perspective. In order to avoid this outcome and move to scenario 3, provision has to be made for those economic actors not able to identify the challenges of climate change or, even if they are able to do so, cannot respond effectively. Support will specifically be needed in providing climate and weather information; access to new and/or better adapted crop cultivars and livestock breeds; access to (improved) technology and farm management practices; access to finance, insurance, energy, storage and transport facilities; and access to markets.

Expansion of market opportunities play a crucial role in today's integrated world economy. While production-side investments that improve productivity and product quality of exportable products can definitely increase Africa's competitiveness, poorly functioning domestic and regional markets – for commodities and services – and costly transport systems add enormously to farmer's production costs and squeeze them out of domestic and international markets. In order to allow African small farmers to take advantage of potential opportunities of higher market integration, what is needed now is increased market development, including the promotion of more formal trading systems, establishing institutions which allow contract enforcement, provision of market information, supporting producer's organisations, developing credit markets and markets for other financial services, and investments in transport, refrigeration and storage infrastructure.

Adapting to impacts of climate change could happen on-farm via new crops, farming technologies and investments in water security, and via market mechanisms. Depending on whether or not markets are working, farmers may be unable to make the necessary adaptations. In many cases, markets are considered unlikely to lead to efficient adaptation. Reasons are uncertainty and imperfect information (e.g. on costs and benefits of adaptation, on timing when costs and benefits accrue, etc.), missing or misleading markets, and financial constraints to invest in adaptive capacity and adaptation (Stern, 2006). Adaptation to new climate realities implies new ways of managing natural resources, adapting crops being grown and the way these crops are grown, or insuring against risks. Without access to functioning markets for farm outputs and production inputs, for information, and for credit, this will be increasingly difficult. Whether or not farmers are able to access markets will also depend on investments in infrastructure, and whether these infrastructure investments are 'climate-proofed' (e.g. are not threatened by flooding, costal erosion or landslides).

Insurance mechanisms provided through markets or in public-private partnerships might become more important in future. Weather-indexed crop insurance practices are currently tested in some countries. Insurance will not help those farmers who confront permanent climate shifts that reduce the viability of agriculture, but it may be relevant for those who face more volatile weather events. Weather-indexed insurance pays out to farmers, based not on their yield losses, but on specific, local weather-related benchmarks. However, establishing effective crop insurance programs raises some challenges. Insurance can be expensive and may not be affordable by the poor people who need it most. The cost is also likely to increase as the probability of more severe weather events increases. Regionally indexed weather insurance may be most cost-effective but need government help getting launched. There may also be a case for subsidizing the insurance for the most vulnerable (IFPRI, 2006).

Enabling small farmers to adapt to impacts of climate change requires making access to knowledge and information essential. This is especially important considering projections that poor countries, which generally have the least level of technological innovation, will be hit hardest by climate change. New ways of sharing innovation and information between private and public sectors to deliver technologies that enable adaptation (and mitigation) must be developed in the next few decades.

Hence, the first bullet in scenario 1 column 2 is a 'headline' for all the actions that donors may fail to take to direct technical expertise and investment in public goods related to the development of "climate change-proof" crops/animals intended for export. The first bullet in scenario 2 column 2 assumes that not all of these actions are neglected and that there is some public support of 'climate change-proof' technology; but it is not provided with a specific focus on facilitating production by labour intensive methods and/or small holders.

Non-aid policies

The other bullet points relate primarily to non-aid policies (though there may be aid implications, for example to help smallholders meet sanitary and phyto-sanitary (SPS) standards). A key policy concerns transport costs. Action to make transport of goods from Africa to Europe more expensive relative to transport within Europe will tend to disfavour an export response. Policies that, by contrast, tackle the domestic carbon footprint of European producers and consumers at least as vigorously as the international carbon footprint will tend to favour exports from Africa, given that the absolute climate change impact of domestic European activities far exceeds that of international transport.

A carbon levy on fuels, as proposed by the president of the Swiss Confederation (Leuenberger, 2006) or proposals to bring aviation emissions into the EU Emission Trading System, could be ways of addressing the growing contribution of the transport sector to greenhouse gas emissions (GHG). Globally, GHG emissions from the transport sector account for 14% of total GHG emissions, with domestic and international road transport contributing 72%, domestic and international air transport 11%, international marine transport 8%, and others 8% (Baumert et al., 2005). A carbon levy (which would make transport more expensive, but because of the much larger share of road transport, which happens largely in developed countries) must be designed in a way that it does not discriminate against African exports. It would be based on the 'polluter pays' principle and is intended to serve two causes: it would encourage major emitters to reduce their emissions, and it would provide sufficient and reliable resources to finance adaptation measures. Additionally, increasing fuel prices can be an incentive for energy-saving investments, as the example of the UK shows, where a 10% increase in fuel prices leads in the longer run (5-10 years) to a reduction in overall vehicle fuel consumption of 6% (RCEP, 2000).

However, overall increasing transport costs may have negative impacts for developing countries, especially landlocked ones. Data for Uganda shows that the effective burden to exporters is very high and amounts to 25% for overland transport (and up to 50% for air fright) of unit price (Rudaheranwa, 2004), and due to a range of causes (taxes, delays in customs clearance, bad roads, etc.) the costs of fertilizer imported into Zambia doubles after it leaves the boat (European Commission, 2005).

There is likely to be strong pressure on European governments to protect the farmers adversely affected by climate change impacts. Unless this is done in ways that are entirely production–neutral (which is very difficult) they will tend to reduce the possibilities for gainful exports by African countries.

A particular case in point concerns biofuels. In a related paper (Peskett, et al., 2007), ODI has argued that it is more likely that increased production of biofuels will reduce food availability in Africa if it occurs in protected OECD markets rather than in the most cost effective places in the world (such as Brazil). Even though African countries may not be significant producers of biofuels, European protectionism in this area (whether by import controls or by directing subsidies for biofuels only to domestic producers) is likely to exacerbate the impact of climate change on global food prices. Hence, it will reduce the volume of food imports that African states can obtain for any given level of export revenue.

Finally, there needs to be attention to ensuring that SPS and other regulatory restrictions on imports achieve their intended public health purpose, are framed in ways that can be achieved equally by small producers as well as by large ones, and do not translate into additional technical barriers to trade. Often, the entire cost of compliance (which can be substantial) accrues solely to the private operators making it infeasible for small producers even to consider exporting. Considerable technical skill is required in the North to design their systems in such a way that they achieve their legitimate purpose but offer methods of compliance that can also be accessed by smaller producers (e.g. group certification, support for local certification capacities, etc.) (Humphrey, 2005).

5. Implications of Climate Change Adaptation for Public Investment and Aid

Coping with climate change impacts is likely to impose a significant additional burden on countries, particularly the most vulnerable ones which are also, to a large extent, amongst the worlds' poorest. How will developing countries cope with such a high level of vulnerability to the vagaries of climate? And, in particular, how will aid and public investment need to respond to make adaptation – from a climate-vulnerable into a climate-resilient environment – effective?

Adaptation to climate change will inevitably require better targeted and, most likely, additional aid and public resources to climate-vulnerable areas, including agriculture. There is a pronounced **temporal dimension** of policy responses and investments in view of the effectiveness of facilitating adaptation to climate change in the agricultural sector. Of specific importance seem to be the next two decades, for which projections of climate change impacts on agriculture are still relatively small and fluctuations will probably remain within historical variations. This implies that investments should aim at:

(i) seizing opportunities for agriculture resulting from climate change where they emerge;

(ii) making agriculture more resilient to climate change impacts (e.g. crop diversification, new/adapted cultivars and breeds, changes in the timing of farm operations, changes in land management practices (conservation tillage, soil and water conservation, etc.), changes in the intensity of production, nutrient and pest management, portfolio diversification (crop / livestock / forestry / fisheries / off-farm income), insurance schemes (formal / informal, public / private), food storage, collection and dissemination of climate and weather information, improved water management and irrigation, development and dissemination of new technologies, guiding and supporting temporary migration in search for complementary off-farm employment or permanent migration); and

(iii) reducing dependence on agricultural income by supporting economic diversification.

Adaptation investments represent an additional burden in the development. These investments can range from 'climate proofing' infrastructure so it can withstand possible climate change impacts such as flooding, coastal erosion, or landslides, and larger fluctuations in rainfall making irrigation infrastructure more costly to furthering agricultural research and technology development. They might also include investments in human capacities to enable farmers to move out of agriculture. Agriculture will need to be given special attention and recent historical agricultural aid and investment trends reconsidered. But crucially, past (and recent) mistakes in the set up of funding modalities and resource allocation formulae should be carefully borne in mind if yet another disappointment with the development process is to be avoided in the future.

5.1 Reversing the agricultural aid and public expenditure downward trend

The recent historical record of support to agriculture in developing countries is not encouraging. Despite the importance of agriculture to economic growth and poverty reduction, the last two decades have witnessed a decline in aid and public expenditure in developing countries' agriculture sector. Official development assistance (ODA) declined by about two-thirds between 1980 and 2002 (from US$ 6.2 billion to US$ 2.3 billion, in 2002 prices). This happened in spite of an increase in the overall volume of ODA by 65% (DFID 2004b). The proportion of ODA channelled to agriculture fell from a peak of 17% in 1982 to 3.7% in 2002. The intra-sectoral distribution of aid also changed. There was a decline in support to agricultural inputs, services (including finance), agricultural education and research, with very few agencies providing inputs such as fertilisers, chemicals, seeds and machinery. Conversely, there was an increase in aid to support agricultural policy and administration (Fan and Rao 2003) with rather unimpressive results.

Government spending in agriculture also declined, not only in aggregate terms, but also in areas where public investment is thought to be of strategic importance (also to build resilience to climate change), such as economic infrastructure and agricultural research and development. The share of total government expenditure in agriculture dropped from 12% in 1980 to 9% in 1998, in a sample of 43 developing countries (ibid). The decrease in public support to agriculture contrasts with a substantial increase in aid to social infrastructure and services, both in relative and absolute terms. Public agricultural research expenditure in sub-Saharan Africa fell from 21% in 1976 to 11% in 1995 (OPM 2002).

In sub-Saharan Africa, the decline in aid and expenditure has happened parallel to the dismal performance of the agriculture sector (with very few stories of success making the exception) – both in terms of productivity, food security and international trade shares.

Climate change will only add further challenges to developing countries' agricultural production, trade and food availability. A determined and urgent policy response is hence needed before the opportunity for adapting a highly climate-vulnerable environment is missed or adaptation costs become prohibitively expensive.

5.2 Policy responses and investment needs for adaptation of agriculture

A number of concrete policy responses related to the scenarios outlined in Section 4.1 are presented in Table 4.1 above. Additionally to these, effective adaptation to climate change will demand carefully targeted investments in other strategic areas to support agriculture and make it more resilient.

- Agricultural research and infrastructures (of transport, communication and marketing) are priority areas to be targeted by adaptation efforts so that more resilient farming systems and technology are developed, and sustainable (and alternative to markets in the North) domestic and regional markets for agricultural products are built.
- Risk management and mitigation capacity will also need to be developed. This should involve not only investments in public sector disaster management

mechanisms but also bring in the private sector and local communities. However, getting the private sector to fill the vacuum in developing countries' insurance markets, for example, will not be an easy task and will require the creation of incentives by governments.

- Investment in diversification promotion strategies will also be essential. This means not only stimulating agricultural diversification (through appropriate extension services) to reduce vulnerability to climate variability but also promoting diversification of income-generating activities outside the agricultural sector and reducing dependency on agriculture.
- In addition, new and very specific governance competences will be required to deal with the new challenges. Governments will also need to devise flexible mechanisms to respond promptly to more frequent weather-related disasters and food crisis.

Many of the above are already part of the list of needs and challenges facing developing countries' agricultural sector, but the increasing variability and uncertainty will inevitably constitute an additional cost on the current agricultural development process. This is particularly true for sub-Saharan Africa where not only the starting conditions are poorer but also the impact of climate change will be relatively more damaging. How will these countries cope with this additional burden, both financially and in terms of human capacities needed?

5.3 Funding adaptation – emerging opportunities in the public sector

The UN Framework Convention on Climate Change (UNFCCC) recognises the right of developing countries to obtain support from developed countries in climate change adaptation, linking it with the underlying development process. Developing countries must thus be helped to move from climate-vulnerable to climate-resilient development (GEF 2006a), and be enabled to 'climate proof' investments, which, according to the World Bank will cost in the range of US$ 10 to 40 billion a year (Müller, 2006).

There have been strong calls for integrating climate change concerns into existing development frameworks, particularly PRSPs, sectoral planning and programmes, and country action plans to support progress towards the MDGs. The Commission for Africa Report (2005) recommends that *'from 2008 donors should make climate variability and climate change risk factors an integral part of their project planning and assessment. They should meet their commitments on funding to help African countries adapt to the risks and impacts of climate change'*. In terms of mainstreaming adaptation within existing poverty alleviation policy frameworks, there has been little progress so far. A World Bank Environment Department report in November 2004 revealed that the average level of mainstreaming of environmental issues in Poverty Reduction Strategies (PRSs) is low. A study on adaptation to climate change in East Africa found that the PRSPs in Tanzania, Uganda, and Sudan do not explicitly mention climate change but only refer to the impact of floods and drought on economic development (Tearfund, 2006).

Three special funds have been established for the purpose of supporting adaptation, with support from the Global Environment Facility (GEF): the Least Developed Countries Fund

(LDCF) and the Special Climate Change Fund (SCCF), both established under the Climate Change Convention and managed by the GEF, and the more recent Adaptation Fund, established under the Kyoto Protocol.

- The LDCF concentrates on Least Development Countries' (LDCs) urgent and immediate adaptation needs. It supports the preparation and implementation of National Adaptation Programmes of Action (NAPAs) – which identify priority interventions whose further delay could increase vulnerability or lead to increased costs at a later stage – by country stakeholders. All LDCs are eligible for this fund and there is no requirement for showing global environmental benefits (GEF 2006a).
- The SCCF focuses on a longer-term and sectoral approach to coping with climate change. It supports (i) adaptation projects in developing countries in selected sectoral areas: agriculture, water, land management, health, infrastructure development, fragile ecosystems, coastal zone management and disaster preparedness (prevention and mitigation capacity), (ii) technology transfer, (iii) energy, transport, industry, forestry and waste management, and (iv) activities to assist developing country parties [...] in diversifying their economies (ibid; Dessai, 2003).
- The Adaptation Fund will complement the above and support adaptation projects in developing countries (parties to the Kyoto Protocol) that are particularly vulnerable to the adverse effects of climate change (such as, low lying and small island countries, countries with low-lying coasts, arid and semi-arid areas, areas liable to flood, drought and desertification, and fragile mountainous ecosystems). This fund is financed through a 2% levy placed on projects in Kyoto Protocol's 'Clean Development Mechanism' (CDM).

These funds are special, and differ from the more dated GEF Trust Fund, in that they are focused on development interventions and support adaptation projects which are fully integrated in wider development projects/programmes. Crucially, these funds apply the 'additional cost' principle[2] rather than the 'incremental cost' principle[3] used as GEF standard practice, thereby recognising that the need to cope with the adverse impacts of climate change imposes an additional burden on vulnerable countries trying to achieve their development goals.

Whilst there appears to be scope for some additional support for agricultural trade and markets, especially under the longer-term SCC Fund, there are a number of outstanding issues which need to be addressed. These include:

- Small size: Table 5.1 overleaf outlines the scale of funding currently available through these new mechanisms. This is currently far short of the predicted levels of funding required to finance adaptation. This raises a question of how additional funding should be provided. Various alternative proposals are being discussed,

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[2] Additional cost refers to the cost needed to carry out adaptation projects which address the adverse impacts of climate change locally.

[3] Incremental cost refers to the cost differential between a baseline action to address a national need and the additional cost of an action which generates global environmental benefits. The application of the incremental cost principles is difficult in the context of adaptation, because most adaptation projects are implemented for their local benefits rather than their global benefits.

such as raising funds through levies on transport (Müller, 2007) and linking private sector carbon finance with adaptation (as outlined in the next section).

- Conditionality and co-financing: some developing countries have been expressing concern with regards to co-financing requirements and 'conditionalities' for funding adaptation projects. Conditionality refers to the conditions placed on accessing funds, such as what types of activities they are used to support and questions of who is liable if fund targets are not met.
- Access: There have also been complaints about the difficulty in gaining access to GEF funding (Müller, 2006).
- Additionality to ODA: There is a general consensus that support for countries to adapting to climate change should be integrated, or 'mainstreamed' into existing development policy to avoid undermining developing countries' wider development goals. This has raised concerns within the development sector and from developing countries, in that existing ODA might be diverted away from its current targets.
- Ownership and governance: An issue currently under discussion in the UN negotiations on climate change is who should be responsible for these funds. In addition to the difficulties to access these funds, there are concerns that such vertical funds, driven and overseen by developed countries, might make effective integration with national development processes more difficult.
- Targeting: One of the most problematic issues for developing country governments will be how to target limited funding into the most effective adaptation responses, given the uncertainties in both the potential impacts and appropriate responses. In agriculture, for example, how should governments find the appropriate balance between strengthening infrastructure against flooding (and hence maintaining access to markets) and supporting farmers to cope with changing land conditions?

Table 5.1: Existing adaptation funding instruments and their scale

Multilateral Donor Funding (status, spring 2006)	Total (Million $)	Pledged (Million $)	Collected (Million $)
LDC Fund	68.3	34.3	34.0
SCC Fund	56.5	56.5	
Adaptation Fund Donations	5.0	5.0	
GEF Strategic Priority on Adaptation (SPA) (part of the GEF Trust Fund)	50.0		50.0
Total Donor Funding	*179.8*	*95.8*	*84.0*
Existing International Private Sector Funding	**Projected**		
Adaptation Fund CDM Levy (projected to 2012)	160-950		
Proposed International Private Sector Funding			
International Air Travel Adaptation Levy (IATAL)	$4,000-10,000 (per annum)		

(*Source*: Müller & Hepburn, 2006)

There is scope for DFID to work with GEF and partner agencies on adaptation issues, contributing to make adaptation better linked with development objectives and processes not only on paper but also in terms of implementation mechanisms. DFID's expertise on matters related to effective aid delivery and management (namely in what concerns the pursuit of the Paris Declaration principles on effective aid) is of relevance to the development of appropriate adaptation funding modalities.

5.4 Funding adaptation - Emerging opportunities in the private sector

One issue with the funds outlined above is that their value is currently very small compared to the estimates of what it would cost to 'climate proof' investments. A potential additional funding source is through the private sector, and particularly through carbon markets. So what are the opportunities for farmers to engage in carbon markets and will these help with their needs in adapting to climate change?

Global carbon markets are currently valued at up to US$ 30 billion (Capoor & Ambrosi, 2006). The CDM, which is a mechanism created under the Kyoto Protocol for developed countries to invest in greenhouse gas reduction projects in developing countries, was worth US$ 2.7 billion in 2005 and is forecast to grow up to US$ 10 billion by 2010. By some estimates financial flows to developing countries through global carbon markets could be worth US$ 100 billion by 2050, equivalent to current levels of ODA (de Boer 2006). Given that (1) soil carbon is the largest terrestrial carbon pool, with more than five times more carbon stored than in living biomass on land; and (2) land use change through cultivation and disturbance is the major driver of carbon losses in the soil, it seems that there would be large potential for bringing agriculture into carbon trading schemes.

Under current policies within the Kyoto Protocol, however, agriculture is not included in regulated carbon trading mechanisms. The only land use activities that are permitted are afforestation and reforestation projects. This exclusion is mainly due to technical difficulties in measuring soil carbon content and the problems of verifying that emissions have been reduced through altered agricultural practices. In future commitment periods of the Kyoto Protocol (post 2012), which are currently under discussion, agriculture might feature in emissions trading systems. If this is the case it is likely that large projects or 'programmatic' approaches will be used, given the difficult technical challenges. Large projects would function like the present CDM, with predictions made about GHG emissions without the project compared to those monitored with the project and payments based on the number of tonnes of GHGs avoided through the project. Programmatic approaches would be sector wide and relate to government policies (e.g. over the types of tillage allowed, erosion control or expansion of farming into new areas) put in place to reduce soil carbon loss. The financial incentives on offer could be considerable for farmers and developing country governments, particularly in certain tropical areas where soil carbon content is high.

Outside Kyoto, voluntary carbon markets already exist in which farmers are rewarded for preserving soil carbon. In Canada, for example, a pilot project involving around 200 farmers aims to remove 53,000 tonnes of carbon dioxide by conversion to zero tillage through direct seeding methods (SSCA, 2006). Farmers will be paid CAD$ 11.08/tonne of carbon dioxide sequestered, which equates to up to CAD$ 13.4 per hectare per year, depending on the soil type.

Could farmers in developing countries benefit from similar schemes? In theory it should be possible for farmers to engage in carbon markets. However, experience with existing carbon markets indicates that in practice it is difficult for farmers to access carbon markets (see also output 3c). The main reasons for this include:

- Lack of technical expertise to engage with what is a highly technical market
- The high risks associated with investment in land use projects (e.g. potential non-permanence of stored carbon) putting investors off
- High transaction costs favouring larger projects and therefore larger land holders

If these barriers can be overcome, a final question is whether such market schemes linked to mitigating further climate change can at the same time help finance necessary climate change adaptation among farmers. There is currently much debate about whether such synergies can be capitalised on and the answer seems to be highly dependent on context. On the one hand are arguments that *"The current emphasis on developing synergies may provide perverse incentives to decision makers to portray their plans (which may well have very laudable goals in their own right) as combined adaptation and mitigation measures, even though they do not make the most efficient use of available resources for adaptation and mitigation."* (Klein 2006) In the case of agricultural systems, they could also lock farmers into systems that make it harder to adapt, such as certain management practices. On the other hand, there may be certain circumstances where mitigation and adaptation activities combine well, such as reforestation to prevent desertification.

In summary, it appears that the carbon market has the potential to benefit farmers in terms of the scale of investment that could be mobilised and carbon could become a new commodity for farmers to trade. However, existing experience in using carbon finance to support the interests of small farmers indicates that in the short term, it is unlikely that they will be able to capture these benefits. Perhaps more fundamentally, there is currently no guarantee that financing through market mechanisms will favour the types of investment that help farmers to adapt to climate change impacts.

6. Policy recommendations

A number of policy recommendations have been described earlier in the paper and will be summarised here. It must be remembered, though, that they have been made in relation to the assumptions in the chosen scenarios and might differ if other assumptions were made.

- Early and marked shift in public support to research and development, extension, market development, rural infrastructure, and services as to specifically, but not exclusively, benefit directly smaller farmers able to produce for export.
- Accompanying development of and support for safety net and social protection programmes for those smallholders unable to make necessary changes to their farm operations.
- Accompanying support to sustainable management of natural resources to make land resources more resilient against climate change impacts where feasible.
- Increase current levels of ODA going towards agriculture to reduce the downward trend of aid in this sector. This is essential even without consideration of climate change. ODA should provide the means and resources to assist developing countries to deal with climate change impacts, but this should be done within the development frameworks as spelled out in PRSPs, sector development programmes and country action plans to support progress towards the MDGs.
- Improve aid delivery mechanisms to increase the flexibility to incorporate climate change measures.
- Consideration of climate change in how such aid flows are used needs to become standard practice. Donors can support this process by developing and providing frameworks for the consideration of climate change and directing funds to support governments through this process.
- There is a need for more analysis of where investment related to climate change in agriculture should be targeted, the potential costs involved and the trade offs between mainstreamed versus non-mainstreamed approaches. Three areas are of particular importance in targeting: (1) supporting agriculture in areas where it is already promoting growth and where climate change is predicted to have potential positive effects; (2) supporting activities such as technology development that will help agriculture in all areas – both low and high potential; (3) supporting diversification out of agriculture and/or alternative forms of aid (such as insurance mechanisms and social protection) which will be especially important for economic growth and in situations where adaptation through agriculture is not an option.
- The level of funding available to agriculture in new funding mechanisms created to address climate change is unclear. Specific funding for agricultural adaptation needs to be identified and if necessary earmarked for access by developing countries.
- Agricultural markets and trade are likely to become more important under most climate change scenarios, especially for sub-Saharan Africa. Funds for adaptation should therefore be specifically targeted at areas that promote the development of a viable agricultural export sector to offset negative impacts of production for domestic markets, market development and improvement, and trade.
- The private sector will also play a crucial role in supporting agriculture under a changed climate and potentially offers new market opportunities, for example through carbon trading, the value of which could exceed ODA. Donors can play a role in increasing opportunities for farmers to access this market through (1) engaging

with international negotiations under the UNFCCC, and regional initiatives such as the EU Emissions Trading System, to ensure that the interests of developing countries are taken into account in the design of these mechanisms and (2) help governments to support the development of the private sector to engage in regulated and voluntary carbon markets more effectively.

7. References

Anim-Kwapong, G., Frimpong, E. (2005) 'Vulnerability of agriculture to climate change-impact of climate change on cocoa production.' Accra, Ghana.

Baumert, K., T. Herzog, J. Pershing (2005) 'Navigating the Numbers. Greenhouse Gas Data and International Climate Policy.' World Resources Institute.

Capoor, K., P. Ambrosi (2006) 'State and Trends of the Carbon Market 2006', Washington, DC: International Emissions Trading Association and World Bank

Davis, C. (2007) 'Global Biofuel Trends.' EarthTrends Update, March 2007. World Resources Institute, Washington.

Dessai, S. (2003) 'The special climate change fund: origins and prioritisation assessment.' Climate Policy, 3 (2003), 295-302.

De Boer (2006) 'Uniting views on climate change', Environmental Finance Interview, November 2006, available at: http://unfccc.int/files/press/news_room/unfccc_in_the_press/application/pdf/ydb_20061106_environmental_financefullinterview.pdf (Accessed 04/2007)

Diao, X., P. Hazell (2004) 'Exploring Market Opportunities for African Smallholders.' 2020 Africa Conference brief 6. IFPRI, Washington.

DFID (2002) 'Better livelihoods for poor people: The role of agriculture.' DFID, London.

DFID (2004a) 'Agricultural Trade and Poverty Reduction: Opportunity or Threat?' DFID, London.

DFID (2004b) 'Official development assistance to agriculture.' Working paper produced by the Agriculture and Natural Resources Team. DFID, London.

Dolan, C., K. Sutherland (2002) 'Gender and Employment in the Kenya Horticulture Value Chain.' Discussion Paper 8. Globalisation and Poverty Research Programme.

European Commission (2005) 'Fact Sheet for the 6th WTO Ministerial Conference.'

Fan, S., N. Rao (2003) 'Public spending in developing countries: trends, determination, and impact', Environment and Production Technology Division Discussion Paper No. 99. IFPRI, Washington DC.

FAO (2003) 'World agriculture: towards 2015/2030. An FAO perspective.' Earthscan, London.

Farmers Weekly (2006) 'Food Miles Endorsements.'

Fischer, G., M. Shah, F.N. Tubiello, H. van Velhuizen (2005) 'Socio-economic and climate change impacts on agriculture: an integrated assessment 1990 – 2080.' Philosophical Transactions of the Royal Society. 360 2067-2083.

GEF (2005) 'GEF Climate Change Strategy', Working Draft. Washington DC: Global Environment Facility.

GEF (2006a) 'Linking adaptation to development', Washington DC: Global Environment Facility.

GEF (2006b) 'Overview of existing programmes and policies to assist adaptation activities', UNFCCC Workshop on the Adaptation Fund, Alberta 3-5 May.

Humphrey, J. (2005) 'Shaping Value Chains for Development. Global Value Chains in Agribusiness.' GtZ, Eschborn.

Huq, S. (2002) 'The Bonn-Marrakech Agreements on Funding.' Climate Policy 2(2002), 243-246.

Klein, R. (2006) 'Climate Policy in the Face of Uncertainty: The Roles of Adaptation and Mitigation', Stern Review Workshop "The Economics of Adaptation" HM Treasury, London, UK, 9 M'ay 2006

GRID (2002) GRID (2002). 'Vital Climate Graphics Africa.' Global Resource Information Database, Arendal.

IFAD (2001) 'Rural Poverty Report 2001 - The Challenge of Ending Rural Poverty.' IFAD, Rome.

IFPRI (2006) 'How will agriculture adapt to a shifting climate?' In: IFPRI Forum, December 2006.

IPCC (2007) 'Summary for Policymakers. Working Group II Climate Change 2007: Climate Change Impacts, Adaptation and Vulnerability.' IPCC, Geneva.

Easterling, W.E., P.K. Aggarwal, P. Batima, K.M. Brander, L. Erda, S.M. Howden, A. Kirilenko, J. Morton, J.-F. Soussana, J. Schmidhuber and F.N. Tubiello (2007) 'Food, fibre and forest products.' Climate Change 2007: *Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (Eds.). Cambridge University Press, Cambridge. 273-313.

Leuenberger, M. (2006) 'A Global Carbon Levy for Climate Change Adaptation.' Sustainable Development Opinion. IIED, London.

MacGregor, J., B. Vorley (2006) 'Fair Miles? The concept of "food miles" through a sustainable development lens.' IIED Sustainable Development Opinion.

McCulloch, N., M. Ota (2002) 'Export horticulture and poverty in Kenya.' Working Paper 174. IDS, Brighton.

Müller, B. (2006) 'Climate of distrust: the 2006 Bonn Climate Change Adaptation Fund Negotiations', Oxford Institute for Energy Studies.

Müller, B., C. Hepburn (2006) 'IATAL — an outline proposal for an International Air Travel Adaptation Levy.' Oxford Institute for Energy Studies.

Müller, B. (2007) 'Adaptation Funding: Politically acceptable governance, adequate additional revenue', presentation at workshop on Climate change and development in Africa: Policy frameworks and development interventions for effective adaptation to climate change. 12 March 2007, Oxford Centre for the Environment. Available at: http://african-environments.ouce.ox.ac.uk/events/2007/12mar07/mueller.pdf (accessed 04/2007)

OPM (2002) 'Agriculture and rural enterprise in Africa: is there an investment gap?' A study for DFID. Oxford Policy Management, Oxford.

Parry, M., C. Rosenzweig, A. Iglesias, M. Livermore, G. Fischer (2004) 'Effects of climate change on global food production under SRES emissions and socio-economic scenarios.' *Global Environmental Change* 14 (1): 53-67.

Peskett, L. (2007) 'A rough guide to climate change and agriculture.' Draft. ODI, London.

Peskett, L., R. Slater, C. Stevens, An. Dufey (2007) 'Biofuels, Agriculture and Poverty Reduction.' ODI & IIED, London.

RCEP (2000) 'Energy – The Changing Climate.' 22nd Report of the Royal Commission on Environmental Pollution.

Rosegrant, M., M. Paisner, S. Meijer, J. Witcover (2001) 'Global Food Projections to 2020. Emerging Trends and Alternative Futures.' IFPRI, Washington.

Rosegrant, M. (2004) 'Looking Ahead: Long-Term Prospects for Africa's Food and Nutrition Security.' In: IFPRI (ed.) Assuring Food and Nutrition Security in Africa by 2020. Prioritizing Actions, Strengthening Actors, and Facilitating Partnerships. Proceedings of an All-Africa Conference, Kampala, Uganda, April 2004. FPRI, Washington. pp. 23-25.

Rudaheranwa, N. (2004) 'Trade costs relating to transport barriers on Uganda's trade.' Economic Policy Research Centre (EPRC), Kampala.

Sing, B.P. (2002) 'Nontraditional Crop Production in Africa for Export.' In: Janick, J., A. Whipkey (eds.) Trends in new crops and new uses. ASHS Press, Alexandria. 86-92.

SSCA (2006) 'SSCA pays farmers for 2005 carbon credits', press release from the Saskatchewan Soil Conservation Association, available at: http://www.ssca.ca/2006.09.06.pdf (accessed 04/07)

Stern, N. (2006) 'Stern Review on the Economics of Climate Change'. Her Majesty's Treasury and the Cabinet Office. London.

Tearfund (2006) 'Overcoming the barriers: Mainstreaming climate change adaptation in developing countries.' Tearfund Climate Change Briefing Paper 1.

UN (2002) 'World commodity trends and prospects. Note by the Secretary-General. A/57/381.' United Nations, New York.

von Braun, J., P. Wobst, U. Grote (2002) '"Development Box" and Special and Differential Treatment for Food Security of developing Countries: Potentials, Limitations and Implementation Issues.' Discussion Paper 47. ZEF, Centre for Development Research, Bonn.

Wangler, Z. L. (2006) 'Sub-Saharan African horticultural exports to the UK and climate change: a literature review.' Briefing Paper for IIED-NRI-DFID project 'Small-Scale Producers and Standards in Agrifood Supply Chains'.

Warren, R., N. Arnell, R. Nicholls, P. Levy, J. Price (2006) 'Understanding the regional impacts of climate change.' Report prepared for the Stern Review. Tyndall Centre Working Paper 90. Tyndall Centre, Norwich.