

## Climate Change, Agriculture and Trade: Implications for Sustainable Development

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## **1. INTRODUCTION**

### **1.1 Agriculture and Development**

Agriculture has played a historically important role in driving national and global development. The industrial revolution, borne out of the need to improve agricultural production, was financed by taxes and sales from agricultural surpluses. The new technologies contributed to an expansion of the agricultural sector with lower production costs (World Bank, 2007a). The increased agricultural growth provided the stimulus for overall economic growth, with a subsequent decline in the overall contribution of agriculture to gross domestic product (GDP) in these industrialised countries. The share of agriculture in GDP is a good indicator of overall economic development, and there appears to be an inverse relationship between GDP and dependence on agriculture. Agriculture contributes substantially to the GDPs of developing countries. On average, agriculture contributed about two percent of the GDP of developed countries in 2004, and 11 percent for the developing countries, with an average of 40 percent for Africa (The World Bank, 2007b).

Agricultural development is strategic to the economic growth of many developing countries. Globally, it is the source of livelihood for about 85 percent of the rural people, and in Africa where more than 80 percent of the population is rural, subsistence agriculture accounts for the livelihoods of about 90 percent, of these rural people, most of them living below official poverty lines. While rural poverty rates have generally declined in other world regions in the past 10 years, the rates in South Asia and Sub-Saharan Africa remained high (between 40 and 50 percent) with a substantial increase in absolute numbers compounded by a rapid population growth rate.

The Millennium Development Goals were developed with the intention of reducing global poverty by 50 percent by 2015. Considering that most of the poor depend directly or indirectly on agriculture for their livelihoods, attempts at addressing poverty should focus on improving their livelihoods. Agricultural development is vital to the achievement of the Millennium Development Goals (MDG) and for stimulating economic growth. Research has shown the effectiveness of agricultural growth in reducing poverty and in sustaining that reduction. Overall GDP growth originating in agriculture is, on average, about twice as effective in benefiting the poorest half of a country's population as growth generated in non-agricultural sectors. Countries that have made significant progress towards achieving the MDGs such as Ghana had relatively high agricultural growth rates (DFID, 2005; World Bank, 2007b). This has motivated the renewed interest by African countries to improve agricultural production in the continent.

### **1.2 Threats to Agricultural Development**

Global agriculture is exposed to several global challenges in recent years. These challenges are environmental, through global environmental change, and economic, through globalization, and both of them are interlinked and self-reinforcing.

#### *1.2.1 Global environmental change*

The world is facing more severe and devastating environmental threats than have previously been experienced. These threats include erosion, land degradation, deforestation, and climate variability and change, which could cause irreversible

damage to terrestrial and marine ecosystems with consequent loss of production potential. About 40 percent of the world's arable land is degraded, and most of the degraded soils are found in the poorest countries, where deforestation, over-exploitation and inappropriate land use practices compound the problem. About 70 percent of the cropland and 30 percent of the pastureland in Africa are affected by degradation and it is estimated that Africa accounts for about 30 percent land degradation of the world (UNEP, 2002).

Extreme climate events are a constant threat to agriculture and livelihoods in many developing countries. More frequent and intense droughts have been observed in the tropics and subtropics, where most of the world's poor reside, since the 1970s. Increased drying linked with higher temperatures and decreased precipitation has exacerbated the drying up of already arid zones in Africa, an iconic case being the drying of the Lake Chad which has affected the livelihoods of the 11 million people who depend on the Lake Chad Basin (Figure 1). Flows in many African rivers have declined by about 40% between 1970 and 2000, with grave implications for irrigation and energy generation (Niassé, 2005). As climatic patterns change, so also do the spatial distribution of agro-ecological zones. For instance, annual rainfall levels have been decreasing in the West African Sahel over the course of this century, with an increase in inter-annual and spatial variability. This has resulted in about 200km southward shift in isohyets (Lebel *et al.*, 1997, L'Hôte *et al.*, 2002). Changing climate patterns have also resulted in changes in habitats, distribution patterns of plant diseases and pests, fish populations and ocean circulation patterns which can have significant impacts on agriculture and food production.

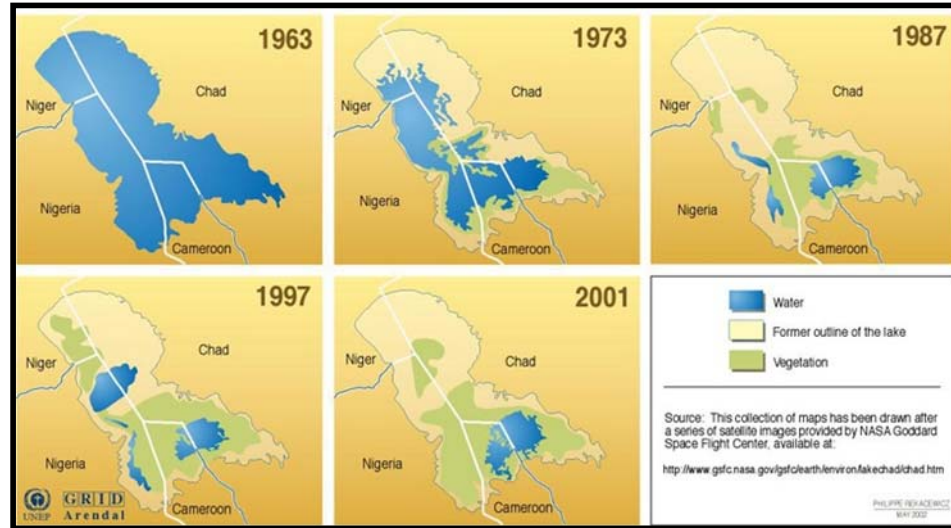


Figure 1: The Disappearance of Lake Chad

### 1.2.2 Global economic change

Another factor that seems to heighten global agricultural vulnerability is globalization. While there is no universally accepted definition of globalization, a common denominator of most definitions is liberalization of trade - international trade. Globalization, if properly handled has immense benefits. It is credited as driving economic growth in many developing countries. China's rapid growth in

agriculture, with a consequent decline in rural poverty from 53 percent in 1981 to eight percent in 2001 has been attributed in part to the liberalization of markets and rapid technology change (World Bank, 2007a). One often cited benefit of globalization is its capacity to create international competition as a spur to innovation and the creator of better and more efficient products and processes.

Although Globalization offers opportunities for growth and development in all parts of the world, developmental challenges faced by many developing countries have made the hopes and promises that should accompany rapid liberalisation of trade unattainable by them. Some of these challenges include low agricultural productivity, a heavy disease burden, particularly the HIV/AIDS pandemic, inflexible production and trade structures, low educational and skill capacity, poor infrastructure, and deficient institutional and policy frameworks (FAO, 2007). These developing countries export a limited range of primary commodities that are highly vulnerable to instability in supply, demand and a decline in terms of trade. The growing integration of markets due to globalization and liberalisation has subjected their economies to a more fiercely competitive external trading environment; a competition they are neither prepared for nor equipped to deal with.

Globalisation has increasingly led to the marginalization of the agricultural sector in many developing countries. For instance, the structural adjustment programme of the 1980s, accompanied by complex market reforms aggravated the vulnerability of many farmers in Africa. Fertilizer prices have risen in response to subsidy removal, resulting in largely negative responses to agricultural reforms. These have hindered the ability of many developing countries to improve their agriculture and to achieve the MDGs of poverty reduction through improving food security and increasing export earnings, benefits that were supposed to accrue from globalization.

## **2. CLIMATE CHANGE AND AGRICULTURE**

### **2.1 The Climate Problem:**

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007) has noted that between 1906 and 2005, the global average surface temperature has increased by about 0.74°C. Eleven of the last twelve years (1995–2006) rank among the 12 warmest years in the instrumental record of global surface temperature (since 1850). The linear warming trend over the last 50 years (0.13°C per decade) is nearly twice that for the last 100 years. The IPCC climate models, considered very conservative, project that global average surface temperature will increase by 1.4°C to 5.8°C by 2100. Recent model runs by the UK's Hadley Centre, incorporating environmental feedback mechanisms suggests that the rise in global mean surface land temperature between 2000 and 2100 is around 3°C greater than projected by previous model estimates. Projections for precipitation show likely increases in precipitation in high latitudes, with likely decreases in most subtropical land regions, by as much as about 20% in some models by in 2100.

Most of the warming observed over the last 50 years is attributable to anthropogenic activities, through the emission of greenhouse gases, mainly carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>) and nitrous oxides (N<sub>2</sub>O), which together are responsible for most of the warming effect, with carbon dioxide being the most important anthropogenic greenhouse gas. As noted by the IPCC, the global atmospheric concentration of carbon dioxide has increased from a pre-industrial value of about 280 ppm to 379 ppm in 2005. About one quarter of the CO<sub>2</sub> concentration in the atmosphere stems

from agricultural sources (land-use change, deforestation and biomass burning), the rest results from fossil fuel use.

The global atmospheric concentration of methane has increased from a pre-industrial value of about 715 ppb to 1774 ppb in 2005. While methane accounts for a smaller fraction of the warming effect, most of it comes from agricultural sources such as domestic ruminants, forest fires, wetland rice cultivation and waste products. The global atmospheric nitrous oxide concentration increased from a pre-industrial value of about 270 ppb to 319 ppb in 2005. More than a third of all nitrous oxide emissions are anthropogenic and are primarily due to agriculture. Conventional tillage and conventional fertiliser use together are the source of 70 percent of the N<sub>2</sub>O. Altogether, agricultural sources are responsible for about 30 percent of global warming. The largest share of the emission of methane and nitrous oxide are from the developing countries, where agriculture plays a major role in livelihood strategies (Figure 2)

It is therefore obvious from the foregoing that agriculture is both a culprit and a victim of global warming. Efforts at achieving sustainable development should seek to reduce the contribution of agriculture to climate change, as well as the vulnerabilities to and impacts of climate change on agriculture.

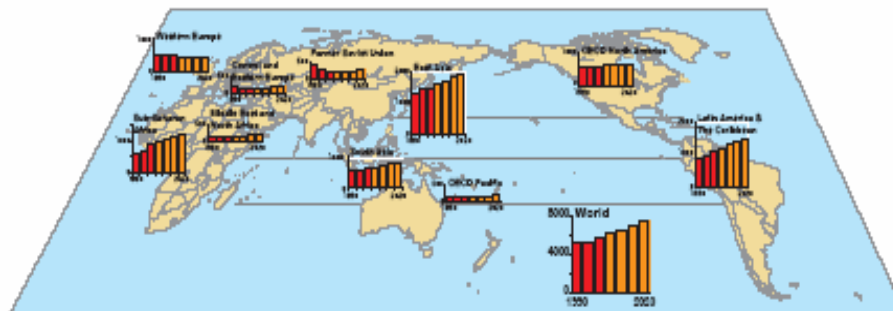


Figure 2: regional Contributions of Agricultural Greenhouse Gases

## 2.2 Impacts of Climate Change on Agriculture

Agriculture is often considered the most vulnerable sector to climate change. As discussed in the previous section, agriculture is affected by the vagaries of climate, and contributes to increasing climate variability and change, directly and indirectly, through the emission of greenhouse gases. Potential impacts of climate change on agricultural production will depend not only on climate *per se*, but also on the internal dynamics of agricultural systems, including their ability to adapt to the changes. This section attempts to summarize the conclusions of the IPCC Fourth Assessment Report (IPCC, 2007). The impacts of climate change on agriculture will be discussed under biophysical impacts, and socio-economic impacts.

### 2.2.1 Biophysical impacts

- *In Mid- to high altitude regions, moderate warming benefits cereal crop and pasture yields, but even slight warming decreases yields in seasonally dry and tropical regions.*

In mid- to high-latitude regions, temperature increases of between 1°C and 3°C across a range of CO<sub>2</sub> concentrations and rainfall changes, will likely have small but beneficial impacts on the main cereal crops – rice, wheat and maize. Further warming beyond this range will likely have increasing negative impacts. In the low-latitude regions, where most developing countries are found, even moderate temperature increases are likely to result in declining yields for the major cereals. This could increase the risk of hunger in many parts of the world. Simulations for sub-Saharan Africa estimate that countries such as Sudan, Nigeria, Somalia, Ethiopia, Zimbabwe, Chad, could lose cereal-production potential by 2080 across all emission scenarios (Fischer et al., 2005). These are countries where a large portion of the population 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. In addition, most of these countries are currently experiencing conflicts that would further hamper agricultural production. However, global warming will also present opportunities for some countries to expand their agricultural potentials.

- *Increases in frequency of climate change extremes may lower agricultural productivity beyond the impacts of mean climate change.*

More frequent extreme events such as floods and droughts may lower long-term yields by directly damaging crops at specific developmental stages. Heavy rainfall could precipitate soil erosion resulting in substantial agricultural loss. Several studies in Africa have established a positive relationship between drought and animal death.

- *Impacts on weed and insect pests, diseases and animal health*

Recent warming trends in Canada and the US have led to earlier spring activity of insects and the proliferation of some species, such as the mountain pine beetle. In Africa, rift valley fever epidemics, which always accompany El Nino events, could increase with a higher frequency of El Nino events. This has a strong negative impact on human and livestock health in the continent.

- *Elevated levels of CO<sub>2</sub> and climate change will have varied impacts on livestock*

Increased CO<sub>2</sub> and global warming will likely produce a dominance of unpalatable and invasive plant species, and could likely have detrimental effects on the nutritional value of extensive grasslands to grazing animals. In addition, increased temperature could lead to thermal stress with a consequent reduction in animal productivity and conception rates. Increased climate variability and loss will result in livestock loss. A temperature increase of up to 2°C could lead to increased net primary productivity in temperate regions, but in the semi-arid and Mediterranean regions, there will be no increase resulting in poor rangeland and fodder for livestock.

- *Changes in Land availability for agriculture*

Agricultural crop distribution and production is largely dependent on the geographical distribution of thermal and moisture regimes. Global warming will likely increase the area that is conducive to growth and production of agricultural crops, as well as extend the length of growing periods in some countries. On the other hand, a significant decrease in land suitable for rainfed agriculture is projected for Africa by 2080, where it is estimated that the area of arid and semi-arid land could increase by five to eight percent. For southern Africa, the area that will likely be unsuitable for agriculture could increase by 11 percent in 2080 because of climate change (Fisher et al., 2005).

- *Climate change will likely lead to increased global timber production.*

Climate change will likely increase global timber production through location changes of forests and higher growth rates from CO<sub>2</sub> concentrations. However, a disaggregation shows a significant variation in regional production.

- *Local extinctions of particular fish species are expected at edges of ranges.*

Fisheries could be affected by different biophysical impacts of climate change. It is likely that regional changes in the distribution and productivity of particular fish species will continue and local extinctions will occur at edges of range, particularly in freshwater species. In some cases, ranges are likely to increase, and decrease in some. A 1.5°C to 2.0°C rise in temperature could result in the loss in productivity on the fisheries in northwest Africa and the East African lakes. A simulation under a doubling of CO<sub>2</sub> indicates that extreme wind and turbulence could decrease global fish productivity by 50 – 60 percent.

### 2.2.2 Socioeconomic Impacts

- *Global cereal production and agricultural GDP*

Most models generally agree that global cereal production would increase by as much as 200 percent by 2080 with global warming because of CO<sub>2</sub> fertilization (Fischer et al., 2005). More disaggregated regional models however have shown the disparity in cereal production at more localized levels. These detailed studies 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 arable land resources are limited, will see reductions in production in the range of 5-10 percent, increases are projected for North America, Europe and the Russian Federation and parts of East Asia.

Several models project that climate change could cause a modest increase of between two and 20 percent in the price of agricultural products in the short to medium term at the global level. While temperature increase of up to 5°C could result in higher output resulting in a small decline in real world cereals prices, global mean temperature beyond that point could lead to a substantial increase in food prices (Easterling et al., 2007; Fisher et al., 2005). With regards to agricultural GDP, climate change could lead to an increase of about 2.6 percent in some areas, particularly the high latitude developed countries and a reduction of about 1.5 percent in others, particularly around the tropics by 2080 (Fischer et al., 2005).

More recent and detailed studies have shown that some parts of sub-Saharan Africa will experience a reduction in magnitude greater than what is predicted with global models. For instance, most of Africa's agriculture is practiced on drylands and the area of semi-arid and arid lands in Africa could increase by about 60 – 90 million hectares (Boko et al., 2007). Model results show that dryland crop revenue falls an average of \$27 per hectare per 1°C increase in temperature, whereas irrigated crop revenue increases an average of \$30 per hectare per 1°C (Kurukulasuriya, et al., 2006). In South Africa, it is estimated that crop net revenues will likely fall by 90 percent by 2100, without effective adaptation (Benhin, 2006). Livestock net revenue in the continent is estimated to fall by an average of \$379 per farm per 1°C. Considering the importance of agriculture to the economy of most African countries, climate change poses a real threat to development in the continent.

- *Food security*

Food security is a function of food availability, food access and food utilization. Climate change could directly or indirectly impact on these three pillars of food security. While the impacts of climate change on food availability and access are well known and documented, fewer studies have examined its impacts on food utilization. For instance, Slingo et al., (2004) have examined the impacts of climate change on the nutrient content of food, while Swaminathan, (2004) and Gommers et al., (2004) have examined how climate change can affect human health and thus the ability to absorb nutrients through increasing vulnerability to diseases. It is estimated that in 2080 about 768 million people will be undernourished (Fischer et al., 2005). Most of the malnourished will be in the developing countries, particularly in sub-Saharan Africa and South Asia, where crop production is projected to decline considerably (Parry et al., 2004). A projected two – three percent reduction in African cereal production for 2030 is enough to put 10 million people at risk of hunger. 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). Some models project that 20-40 poor and food-insecure countries may lose on average 10-20 percent of their cereal-production potential under climate change.

### 3.0 CLIMATE CHANGE MITIGATION AND ADAPTATION IN THE AGRICULTURAL SECTOR

#### 3.1 Mitigation

Agriculture contributes about half of the global emissions of two of the most potent non-carbon dioxide greenhouse gases – nitrous oxide and methane. Nitrous oxide emissions from soils (from fertilizer application and manures) and methane from livestock production each account for about a third of agriculture’s total non-carbon dioxide emissions and are projected to rise with climate change. The rest of non-carbon dioxide emissions are from biomass burning, rice production and manure management. Agriculture is also a major contributor of reduced carbon sequestration (storage) through deforestation and land use change. Agriculture therefore offers excellent opportunities for reducing GHGs. Considering that most of the agricultural contribution to GHG is from the developing countries; about 70 percent of the economic potential for mitigation is in the developing countries (Figure 3).

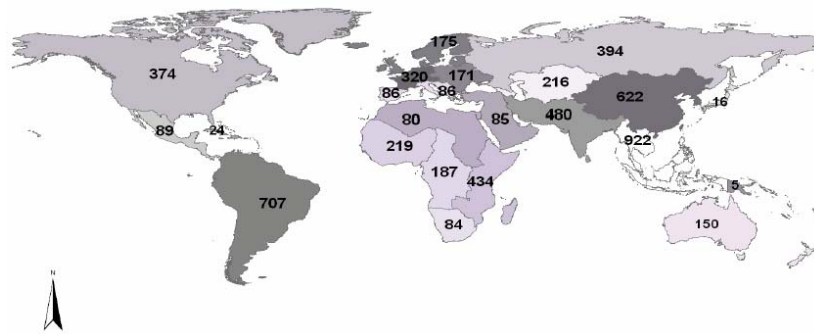


Figure 3: Regional Distribution of Economic Potential (at US\$ 100/tCO<sub>2</sub>-eq) by 2030

### 3.1.1 Mitigation options

Mitigating climate change requires identifying effective ways to reduce greenhouse gases produced and released to the atmosphere. Various mitigation options have been considered in the agricultural sector. These include: cropland management, grazing land management and pasture improvement, management of organic/peaty soils, restoration of degraded lands, livestock management, manure management, and bioenergy. Many of those approaches have win-win outcomes in higher productivity, better management of natural resources, or the production of valuable by-products, such as bioenergy. Others require substantial investment at the global level, such as the development of low-emission rice varieties and livestock breeds. The potential for each of these mitigation options is presented in Figure 4.

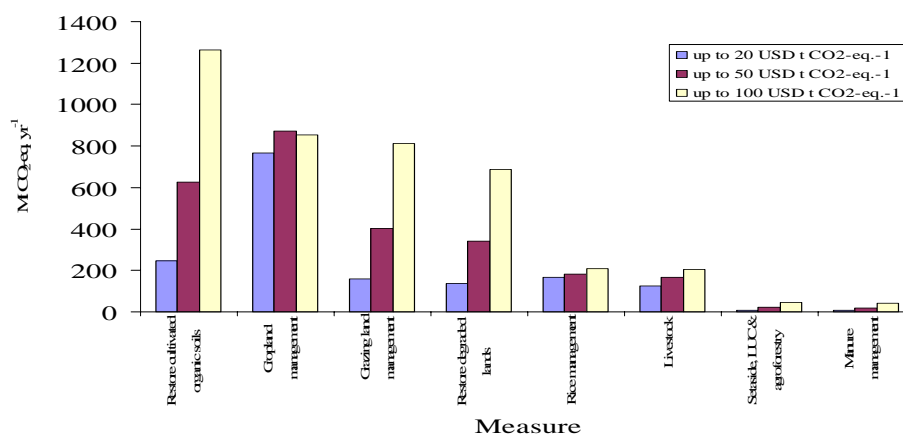


Figure 4: Effect of Carbon Price on Mitigation Implementation (Smith 2007)

About 90 percent of mitigation potential in agriculture is through better cropland management. Some of the recommended practices for better cropland management include:

- Agronomy: –implementation of agronomic practices that give higher yields and residues, which can increase soil carbon. It also involves the development of better crop varieties, and use of cropping rotations and cover crops.
- Nutrient management: This involves improving the efficiency of Nitrogen use. Since fertilizer is responsible for large amounts of Nitrous oxide emissions in the agricultural sector, farmers can be encouraged to choose management practices that lead to appropriate fertilizer application rates, Nitrous oxide emissions can be reduced by avoiding costly fertilizer over-applications.
- Tillage/residue management: Practices include low zero-tillage crop management practices, and the retention of residues on farms.
- Water management: This involves the improvement of yields through good and efficient irrigation practices, and better water management.
- Rice management: Rice production is responsible for a large proportion of methane emissions from agriculture. These emissions are generated through the cultivation of paddy rice, which promotes the anaerobic decomposition of plant wastes that remain after the harvest. Reductions in methane emissions can be achieved by cultivating low CH<sub>4</sub> emitting varieties, improving water management practices, and using inorganic fertilizers.

- Agro-forestry: Establishment of shelter belts, riparian buffer strips with woody species
- Land cover (use) change: Converting cropland to grassland; reversion of cropland to natural vegetation.

However, it must be noted that these options are not universally applicable – individual countries should evaluate their circumstances and their applicability based on their land use and management, and climate and social settings. They must also consider uncertainties that may be associated with these options such as the level of adoption and potential barriers to such adoption, the technical effectiveness of each of the options, and the persistence of mitigation.

### 3.1.2 *Incentives for mitigation*

Certain incentives exist and more should be created to encourage developing countries to mitigate climate change in the agricultural sector. Such incentives include:

- *Carbon Trading*: The emerging market for trading carbon emissions offers new possibilities for agriculture to benefit from land uses that sequester carbon, thereby enhancing carbon storage in soils and avoiding deforestation. However, the implementation of the various mitigation strategies will also be driven by the price of carbon. Higher prices of carbon will encourage greater implementation of mitigation options.
- *Expansion of CDM to include afforestation and reforestation projects*. Many of the potential CDM projects in the developing countries would naturally revolve around afforestation and reforestation. Unfortunately, these are not covered in the existing CDM structure. Post Kyoto negotiations should address this. This expansion should also include the possibilities of earning carbon credit through carbon sequestration in soils (for example, through conservation tillage) and for agro-forestry in agricultural landscapes. It is estimated that for the next 20-30 years, cropland contribution to carbon sequestration lies within the range of 450-610 million tones of carbon per year (FAO, 2003). For farmers to benefit financially from these practices, policymakers will have to develop acceptable systems for inventorying and monitoring soil carbon in agricultural lands.
- *Incentives for investment in science and technology for low-emission technologies*. The “public good” nature of research in this area warrants international support for innovative, cost-effective solutions that will reduce emissions from livestock and rice paddy fields through advances in breeding and through the use of advanced technologies.

### 3.1.3 *Mitigation trade-offs*

It is obvious that some mitigation practices that benefit agriculture can have adverse impacts in another sector. Draining the land under rice cultivation can adversely affect wildlife habitat, reduce wetland acreage as well as reduce wildlife benefits. There are also mitigation practices that have co-benefits. For example, reducing nitrogen fertilizer use can improve water quality and reduce nitrous emissions. Also, providing riparian buffers can enhance wildlife habitat, improve water quality, and increase carbon storage.

## 3.2 Adaptation

Adaptation is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. With impacts on the agricultural sector manifesting from both climate variability and long-run climate change, the type of adaptation option that is implemented is clearly crucial. Adaptation to climate impacts, particularly in the agricultural sector in particular, is not a new phenomenon. While climate variability impacts will be essentially local in scale, climate change will affect long-term trends. This section briefly reviews various adaptation strategies in the agricultural sector that address both the short and long term impacts.

### 3.2.1 Adaptation in the short term

This typically is adaptation that addresses short term climate variability. These include first, farm-level responses such as planting different crop varieties, changing planting dates, crop and livestock diversification, changing land use practices, adapting practices to a shorter growing season, rotating or shifting production between crops and livestock, and shifting production away from marginal lands. Short-term adaptation strategies specific to the livestock sector include shifts in biological diversity, species composition and/or distribution. The options also include change in grazing management (timing, duration, and location) varying supplemental feeding; changing the location of watering points; altering the breeding management program; changes in rangeland management practices; modifying operation production strategies as well as changing market strategies (Kurukulasuriya and Rosenthal, 2003).

A second type of short-term adaptation involves the reliance on risk coping financial mechanisms. Agricultural insurance is widely recognized as a veritable strategy for spreading risks, including climate induced risks in the agricultural sector. It can enhance financial resilience to external shocks and provide a unique opportunity to spread and transfer risk. They may provide incentives for risk reduction and prevention while engaging the private sector in climate change response action. One of the benefits of promoting insurance-related actions is that it may help advance efforts on quantifying risks and potential losses due to climate change (UNFCCC, 2007). Minimizing risk can result in a reduction of the rates for insurance, which thereby become more affordable.

Currently, the insurance market is very limited in developing countries, although it is a vital instrument for these countries, particularly for coastal communities and sectors such as tourism. Current limitations are, in part, due to limited economic assets and limited private sector interest in insurance, and the weak financial institutions in these countries. Consequently, there is a greater dependence on informal risk coping strategies such as risk pooling

In response to the growing realization that insurance solutions can play a role in adaptation, as suggested in the UNFCCC and the Kyoto Protocol, the Munich Climate Insurance Initiative was initiated in 2005 to develop insurance-related solutions to climate change, including identifying and promoting loss reduction measures, in cooperation with other organizations and initiatives and conduct pilot projects.

A third short-term adaptation strategy is temporary migration. It is common to find migrant farmers who relocate from drought-affected areas to more favourable regions to farm and return when conditions improve. Sometimes, families agree to send

family members to work in other regions or countries who will in turn support the family through remittances. These remittances have often contributed significantly to providing the needed credit to buy farm inputs and implements to improve agricultural productivity.

### *3.2.2 Adaptation in the long term*

These strategies are often implemented as a planned adaptation to address long-term climate change. These strategies include development and adoption of new technologies and reducing greenhouse gas emissions. The technologies include soft technologies such as information systems, management practices, new crop cultivars, etc, and hard technologies such as mechanical equipment for irrigation, conservation tillage, and integrated drainage systems. While these adaptation options can be numerous, they are often site- and sector-specific and reflect numerous decision rules. For instance, such rules should include considerations of the extent of belief that the climate is actually changing; awareness of the type and form of change; knowledge of technology, not only today but also in years to come; and assumptions about what governmental policies will be in various regions and over time. Mitigation is still the best adaptation strategy and developed countries should set more aggressive targets to reduce greenhouse gas emissions.

## **3.3 Other Issues Pertinent to Mitigation and Adaptation**

### *3.3.1 Food miles*

'Food miles' refers to the distance a food product travels from field to plate. The debate is based on the premise that the use of air and road transport adds to the carbon dioxide emissions, which are contributing to climate change. In response to this, consumers, particularly in the developed countries are advocating to buy food that is produced locally. This has the potential to dampen the demand for fruit and vegetable exports from Africa significantly.

Whereas it is difficult to argue that developing countries should be exempted 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. For example, recent studies have shown that the emissions produced by growing flowers in Kenya and flying them to the UK can be less than a fifth of those grown in heated and lighted greenhouses in Holland. In discussing the food miles, it is necessary to also take into consideration the social cost of carbon emissions with the benefits that arise from trade. In Kenya, for example, carbon emissions are 200kg a head, while in the UK they are almost 50 times that (MacGregor and Vorley, 2006).

Action against food miles 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. An important element that is missing from the debate on food miles is the important contribution agricultural exports make to the livelihoods of a large number of African farmers. It is estimated that almost a million African farmers and their families rely on the fruit and vegetable trade with the UK. The horticultural export industry is providing jobs to about 2 million people in Kenya. 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).

African economies are currently growing by around five percent or more – in part due to agricultural exports. Agriculture remains the most likely source of economic growth and poverty reduction in most African countries. If Africa is to grow by seven percent and achieve the Millennium Development Goals, it must be free to trade with the rest of the world. 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. There is the need to rethink the logic of food miles and communicate same to consumers (MacGregor & Vorley, 2006).

### *3.3.2 Virtual water and ghost acres*

Global models are not unanimous about how global warming will influence the magnitude and patterns of precipitation. However, it is generally agreed that many areas will experience a drying that will negatively affect the hydrological cycle. Many governments are therefore becoming more interested in where their limited water supplies are going and what they are being used for. This raises the question of virtual water and ghost acres.

Virtual water is calculated in terms of water that is used to grow crops that are exported to or imported by other countries. So, water that is used to grow flowers in Kenya, for example, is actually serving as supplemental water supplies for other countries that import the flowers. That is opportunity cost for the exporting countries as such water is not being used to generate energy or produce food in those exporting countries. A country that is importing wheat rather than producing it is in fact borrowing water supplies from the exporting countries.

It is estimated that annually, the UK “imports” 189 million m<sup>3</sup> of African water through the import of green beans. This is enough to provide 10 million Kenyans with drinking water (McCulloch & Ota, 2002). Given that Kenya is categorised as a water-stressed country, and this is forecast to worsen, the implications for an expansion of the green bean trade need to be investigated. However, this does not necessarily help improve water resources management in Kenya, where the chief cause of water-stress is poor water infrastructure, not agriculture diverting water from the population. While there are no clear guides on these, governments must evaluate the virtual water issue in terms of climate change and its food balance equations, and in terms of its water and food security situations.

‘Ghost acres’ refers to the amount of land that is used to cultivate food that is exported to support other countries. Like virtual water, ghost acres should also be taken into consideration in the food security equation and in the climate change debate.

### *3.3.3 Carbon leakage and embodied carbon*

In attempts to reduce carbon emissions, many developing countries are outsourcing production for their domestic consumption to other developing countries that are not bound by the Kyoto protocol, and are still using inefficient production technologies. While there is an increasing number of studies on carbon embodiment in trade, research on embodied carbon in agricultural trade is still at its infancy. However, as

noted by Bin and Harris (2007), quantifying carbon associated with international trade will shed light on opportunities and priorities for implementing emissions mitigation programmes that might succeed the Kyoto protocol.

#### *3.3.4 Biofuels*

With oil prices at an all-time high and with few alternative fuels for transport, several countries are actively supporting the production of liquid biofuels from agriculture. Biofuels offer a potential source of renewable energy and could lead to large new markets for agricultural producers. With the rising use of biofuels has also come debate regarding the potential positive and negative impacts of this product. While proponents of biofuels point to the potential for cleaner fuels, greater economic opportunities for farmers and rural communities and a renewable source of energy, detractors argue that biofuels risk damaging biodiversity resources, marginalizing local communities and indigenous groups and creating more greenhouse gas emissions than they prevent.

This debate is complicated by the fact that numerous types of feedstocks can be used in the production of biofuels. Depending on the feedstock used, where and how it is grown and the manner in which it is processed, the greenhouse gas balance, energy yields and environmental impacts of biofuels may differ greatly (The Royal Society 2007). In addition, depending on what assumptions and methods are used in estimating the impact of biofuels the magnitude of the potential impacts can vary significantly. Further complicating the situation is the fact that biofuel technology and policies are evolving at a rapid pace. Given this complexity it is not possible to generalize the specific impacts of biofuels as each fuel type and system of production has different potential impacts.

Several studies emphasize that the production of biofuel crops could have a negative impact on water resources, especially when traditional field crops are used (De fraiture et al., 2007; Berndes, 2002). Certain crop such as oil palm, sugar cane and maize can have very high water requirements, which lower their water use efficiency (Steenblik 2007, Rajagopal and Zilberman, 2007).

The production of biofuel feedstocks could also have a variety of positive and negative impacts on socio-economic conditions. As the majority of feedstocks used in the production of biofuels are agricultural, the market for biofuels and agricultural products are closely related (Doornbosch and Steenblik 2007). The rising demand for agricultural biofuels is translating into higher market prices for some agricultural products. Biofuels, by using agricultural crops for feedstocks, reduce the amount of crops and land available for food production, resulting in higher commodity prices even into the next decade (UNCTAD, 2007). The clearest example is maize, whose price rose by over 60 percent from 2005 to 2007, largely because of the U.S. ethanol program combined with reduced stocks in major exporting countries. The price of all crops used in the production of biofuels, with the exception of sugar, has increased dramatically in the same amount of time.

## **4.0 CLIMATE CHANGE IMPLICATIONS ON INTERNATIONAL AGRICULTURAL TRADE**

### **4.1 International Agricultural trade**

Very few countries aim for, or achieve, food self-sufficiency; trade in food and other agricultural products is the norm. The rules that guide the global trade system, including agricultural trade are normally dictated and enforced by the World Trade Organization (WTO). Many proponents have advocated for trade liberalization as a panacea to economic development. Arguments in favour of liberalization have noted that when trade is liberalized, developing countries will benefit from improvements in their access to markets in other developing countries. This, it is argued that the barriers against south-south trade are larger than those in the industrial countries, and developing countries are important markets for developing country exporters.

Another argument is that liberalization will benefit the rural sectors of these countries, where poverty is concentrated, because of higher world agricultural prices. For instance, net farm incomes are predicted to rise by an average of seven percent for Africa as a whole, which will substantially offset the loss in GDP from climate change impacts. The bottom line effect on poverty would be to lift almost 32 million people out of poverty worldwide, about two thirds of them in Sub-Saharan Africa (McCall and Nash, 2007).

While the benefits of trade liberalization are undeniable, the hopes and promises touted by trade liberalisation have not so far been fulfilled in many developing countries. Many developing countries are increasingly becoming marginalized, especially in agriculture. Trade liberalization is a real threat to agricultural development and trade in the developing countries. Agricultural trade is increasingly favouring developed countries, as poor countries have had to cut support to farmers and open their agricultural markets to rich countries.

Agriculture is often the economic driving force in developing countries. WTO statistics show that agriculture accounts for over one-third of export earnings for almost 50 developing countries, and for about 40 of them this sector accounts for over half of export earnings (WTO, 2000). The higher tariffs on agricultural products compared to manufactured goods in high income countries is a barrier to market access by poor developing countries that depend largely on agriculture for export earnings.

In addition, many developing countries face inherent challenges that make them less competitive in the global agricultural trade arena. Some of these challenges include low productivity, inflexible production and trade structures, low skill capacity, low life expectancy and educational attainments, poor infrastructure, and deficient institutional and policy frameworks. At the same time, with the growing integration of markets due to Globalization and liberalisation, their economies face a more fiercely competitive external trading environment. Many of them continue to export a limited range of primary agricultural commodities that are highly vulnerable to instability in supply, demand and a decline in terms of trade.

In view of the pivotal role that agriculture plays in the development of many developing countries, it seems very likely therefore, that agricultural trade will form an increasingly important part of the attempts by these countries, particularly in sub-Saharan Africa, to maintain adequate food supplies and continue to stimulate economic development and poverty reduction. However, significant agricultural subsidies provided by OECD country governments to their farmers compromises the

ability of developing country farmers to participate in global agricultural trade reducing their income and profit streams and their ability to escape poverty. Studies have shown that so far trade liberalization has not been closely associated with poverty reduction. In fact, based on an IMF index of trade restrictiveness, UNCTAD estimates that poverty is increasing in those developing economies that have the most open trade regimes.

## **4.2 Agricultural trade and climate change linkages**

### *4.2.1 Effects of climate change on agricultural trade*

The links between climate change and international agricultural trade and markets are obvious. The supply of agricultural produces within a country is a function of: the volumes produced domestically, the price of imports and the price of the exports used to generate foreign exchange. Climate change could affect all three of these variables (Ludi et al., 2007). Previous sections have shown how climate change could directly affect agricultural production.

Trade plays an important role in maintaining equilibrium on food availability during periods of variable climatic conditions as more food is imported by countries that experience shortfalls in crop production due to insufficient rains as was the case in South Asia in the late 1980s. Also, trade will play an important role in enabling countries moderate the impacts of climate change on crop by enabling farmers in regions less adversely affected to sell their produce in areas more severely affected by climate change.

Climate change can have a direct or indirect effect on the price of agricultural imports. Climate models have shown that increased production from the areas that will 'benefit' from climate change will be smaller than the decline in those that will 'lose' global supply. This will most likely lead to a rise in agricultural prices. This direct impact is additional to the other influences on global demand and supply (such as rising incomes, increased population and hence demand and increased drive for production of biofuels).

Some climate change mitigation strategies will have implications for agricultural prices. In an effort to reduce consumption of fossil fuels and hence cut greenhouse gas emissions, there is a significant global increase in the production of biofuels. This has contributed to the current food crisis by raising agricultural prices by diverting agricultural resources away from food production.

Many developing countries generate a large part of the foreign exchange required to fund imports through the export of agricultural goods. In sub-Saharan Africa, this forms 50 percent of the region's export earnings. 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. Policies to reduce food miles could raise the price of vegetables and flowers in import countries while causing a glut in export countries, thereby reducing the ability of many developing countries to earn foreign exchange to participate in the international market.

Climate change can directly affect trade-related infrastructure, or trading routes. For instance, rising sea levels may endanger coastal infrastructure that supports trade, such as ports. In addition, extreme weather events can be expected to disrupt markets and infrastructure. One of the predicted effects - increased flooding - will affect infrastructure as well as transport routes, as was the case during the 2000/2001

flooding in Mozambique where roads and railway lines were washed away. This is against the backdrop that Africa's road infrastructure is worse than any other continent. As noted by Sachs et al., (2004), before high-intensity modern trade can get started, Africa needs an extensive road system both from the coast to the interior and within the interior, where the highest population concentrations are found. These roads, however, are very expensive to build and maintain. Destruction of the existing roads will severely affect trade in Africa.

#### *4.2.2 Climate change and agricultural trade policies*

Climate change and trade are governed largely by two different bodies, the United Nations Framework Convention on Climate Change (UNFCCC) and the World Trade Organization. Under the UNFCCC, the most visible effort at mitigating climate change is the 1997 Kyoto protocol. The overall objective of the Kyoto protocol is the betterment of current and future human welfare, an ideal also shared by WTO. Yet both climate and trade agendas have evolved largely independently through the years, despite their mutually supporting objectives and the potential for synergies.

*Trade Liberalization:* Trade liberalization is expected to lead to improvements in access to international markets, which in turn can help a country diversify and reduce the risk of food shortages from climate change. This is based on the assumption that the trading system is a risk spreading mechanism through the geographic relocation of world food supplies according to changing comparative advantage and spatial diversification of climatic risks.

However, it is important to note that trade policy of the WTO might serve to facilitate or hinder efforts to address climate change mitigation and adaptation. For instance, while trade liberalization would encourage an increase in the scale of production to reduce transaction and production costs, the scale effect will, in and of itself, have negative climate change impacts; the more goods and services produced under present technologies, the more greenhouse gases (GHGs) emitted. Increased trade through liberalization will obviously lead directly to more global GHG emissions from increased transport of goods. The GHG-intensity of transport varies enormously from marine transport to trucks to airfreight, but ultimately, all modes of transport have some emissions. Trade liberalization could have beneficial impacts on mitigation strategies where investment agreements may bring new techniques of production that are more energy efficient, and therefore emit fewer GHGs per unit of output. This may be due to foreign investors bringing new technologies, or domestic firms having to increase efficiencies in the face of foreign competition.

*Tariffs:* Another specific WTO trade policy that might affect efforts to combat climate change is the tariff structure. It is generally argued that high tariffs on imported goods, and other trade restrictive policies can reduce the effectiveness of trade as well as impede the entry of efficient technologies into new markets. This has implications for technology transfer to combat climate change. This has led to calls for reductions in agricultural tariffs and subsidies noting that the removal of distortions in global agricultural activities is likely to improve allocative efficiency in agriculture and improve aggregate welfare if it is accompanied by the removal of farm support mechanisms. Others have argued that there should be selective tariff lowering, if at all, as lower tariffs can aggravate climate change impacts. For instance, lowering tariffs on paddy rice is likely to aggravate climate change through increased methane production.

#### *4.2.3 Climate change, comparative advantage and competitiveness*

Climate change will have significant impacts on agricultural trade flows. In general, the impacts of this type will involve changes in comparative advantage based on environmental factors. Kenya's role as a tea-exporting powerhouse, for example, may be under threat from climate change-related drought in the long term. The same applies to other products and countries. A country that has comparative advantage today in the production of a particular agricultural commodity may lose that advantage in the future due to climate change threats.

Most countries want to remain competitive in their trade transactions, and many firms are driven by profit. The decision by many countries to mitigate climate change could affect the competitiveness of their firms. First, there is the prospect that a country that takes strong climate change measures may put its firms or sectors at a disadvantage relative to their foreign competitors in countries that do not take such strong measures. This may lead to the "leakage" problem and encourage embodied carbon, where strong regulations could cause offending firms to relocate to other areas where mitigation requirements are not stringent. Second, there is the concern that even among those countries taking strong action, Parties may create unfair competitive advantages for domestic industry by the manner in which they implement their climate change policies. For instance, by imposing high tariffs on products from countries whose production systems are not climate friendly.

### **5. IMPLICATIONS FOR SUSTAINABLE DEVELOPMENT**

For a long time, climate change has been viewed largely as an environmental issue of little relevance to development. For the same reason, development approaches have not been given the necessary attention by the climate change community who instead focused on reducing greenhouse gas emissions. This state of affairs is partly to blame for the heavy price countries continue to pay whenever climate disasters strike and resources diverted to attend to such events instead of having long-term strategies that may not only minimize the impacts but also ensure resources meant for development are not diverted to deal with such emergencies.

Climate change has can potentially undermine whatever modest gains have been achieved towards meeting the MDGs. It is therefore important that climate change be mainstreamed into developmental policies and plans. While climate change will likely affect development at various levels, the development approach chosen will also influence future emission of greenhouse gases as well as the adaptive capacity of individuals, communities and countries. According to Huq et al, (2006), unsustainable development is the underlying cause of climate change and development path taken determines the degree to which society is vulnerable to climate change.

Poverty is a strong impediment to achieving sustainable development and agriculture holds the key to reducing poverty in many developing countries. The large share of agriculture in GDP in low-income countries suggests that strong growth in agriculture is necessary for overall economic growth. Indeed, agriculture accounted for about one-third of growth in Sub-Saharan Africa over the past 15 years. As GDP per capita rises, agriculture's share in GDP declines, and so does its contribution to growth.

Unfortunately, agriculture appears to be the most vulnerable sector to the adverse impacts of climate change. To achieve sustainable development, efforts need to be stepped up to mitigate and adapt. Both strategies are very important and should be

pursued concurrently. The developed countries need to actively pursue strategies to reduce greenhouse gas emissions. Even if greenhouse gas were stabilised in the atmosphere today, global warming would continue for a long time.

Climate change requires a global framework for international cooperation. Adaptation action is a vital part of this framework. Actions to enable adaptation to climate change pose opportunities to promote sustainable development. Developing countries require resources in order to promote these actions. A successful framework must directly involve assistance for adaptation in developing countries, particularly small island developing States and least developed countries, given that they will disproportionately bear the brunt of climate change impacts. Combating climate change is vital to the pursuit of sustainable development; equally, the pursuit of sustainable development is integral to lasting climate-change mitigation.

## **6. WHAT THE INTERNATIONAL COMMUNITY CAN DO**

With respect to climate change, there is a lot that the international community can and needs to do. First, the UNFCCC tasks the Annex 1 countries to support non-Annex 1 countries to reduce their vulnerability to climate change. This is beyond just providing finances as aid to the developing countries. The Annex 1 countries have a moral responsibility to substantially reduce their greenhouse emissions to a level that will reduce the extra burden that climate change poses to poor developing countries. While many of these countries have signed the Kyoto protocol, they are yet to have clear-cut plans and strategies to meet the commitments of the Kyoto protocol. Just as the world, concerned with the state of poverty in the developing countries came up with the MDGs – measurable and achievable targets, the same needs to be done regarding green house gas emissions.

The international community should also support adaptation in the developing countries. One reason for Africa's high vulnerability to climate change is its low adaptive capacity. Efforts should be made to improve this adaptive capacity. Adaptation is already considered a vital part of any future climate change regime. Within the UNFCCC and the international community, deliberations are building to find an effective means to tackle climate change. Future decisions within the UNFCCC negotiating process must assist developing countries in a streamlined, innovative and transparent way, with transfer of knowledge, technology and financial resources to adapt and to adapt at all levels and in all sectors. If there are delays in implementing adaptation in developing countries, including delays in financing adaptation projects, this will lead ultimately to increased costs. Delays in implementing adaptation will also lead to greater dangers to more people. For example, extreme events including droughts and floods could trigger large-scale population movements and large-scale conflict due to competition over scarcer resources such as water, food and energy.

The international community can further support the development and transfer of low-carbon intensive technologies to developing countries. Most developing countries are in a position to chart a path towards green development without following the model of the present industrialised nations. This would require financial and technical assistance from the developed countries.

The international community can further increase research funding for Africa. Despite several efforts, global research into areas critical to African development remains woefully under-funded. For example, the annual operating budget of \$400 million for

the worldwide network of sixteen tropical agricultural research centers known as the Consultative Group on International Agricultural Research (CGIAR) is minuscule compared with the research and development (R&D) budgets of the world's six largest agrobiotech companies, estimated at roughly \$3 billion a year (Sachs et al., 2004). The budget of the CGIAR system as well as of the national agricultural research centers remains low despite considerable evidence of the high social rates of return from R&D in tropical food production.

There is the need to reform agricultural trade and increase developing countries' presence in international trade. For instance trade discrimination against Africa has persisted for decades despite repeated promises to remove limits on Africa's access to U.S. and European markets. Even new initiatives to expand access to the U.S. market, such as the African Growth and Opportunity Act, remain heavily constrained by rules-of-origin and other limits to African exports. It is important to ensure that subsidised crops from the North and market protection do not undermine the efforts of farmers in Africa to sustain their livelihoods. Trade justice should be promoted by ensuring that governments, particularly in poor countries, can choose the best solutions to end poverty and protect the environment. These may not always be free trade policies. Export subsidies that damage the livelihoods of poor communities around the world may need to be abolished.

## **7. CONCLUSION.**

Agriculture holds the key to economic growth in the developing world. However, agriculture will be severely impacted by climate change. There is the need to reduce greenhouse gas emissions as well as adapt to the adverse impacts of climate change. Agriculture is both a culprit and a victim of global warming. Properly managing agricultural practices could contribute substantially to climate change mitigation. Efforts are increasing to get developing countries to adapt to the adverse impacts of climate change. There are however, limits to adaptation. The potential for adaptation should not lead to complacency. Agricultural adaptation to climatic variation is not perfect, and changes in how farmers operate or in what they produce may cause significant disruption for people in rural regions. Indeed, some adaptive measures may have detrimental impacts of their own.

While trade liberalisation holds a lot of promise for agricultural development. A completely liberalised market will not bring the same benefits to all countries. It may cause difficulties for some developing countries, in particular those dependent upon food imports or those losing preferential access to markets. Measures will be needed to help these countries to adjust. Nevertheless, in the long term, liberalisation should result in a more favourable international structure of agricultural prices, which should benefit most poor countries. The most pressing challenge is to address the environmental and economic challenges of the poorest nations to reap the benefits of agricultural production in the bid to achieving sustainable development and achieving the MDGs. There is the need for

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