CLIMATE CHANGE IMPLICATIONS FOR AGRICULTURE IN SUB-SAHARAN AFRICA

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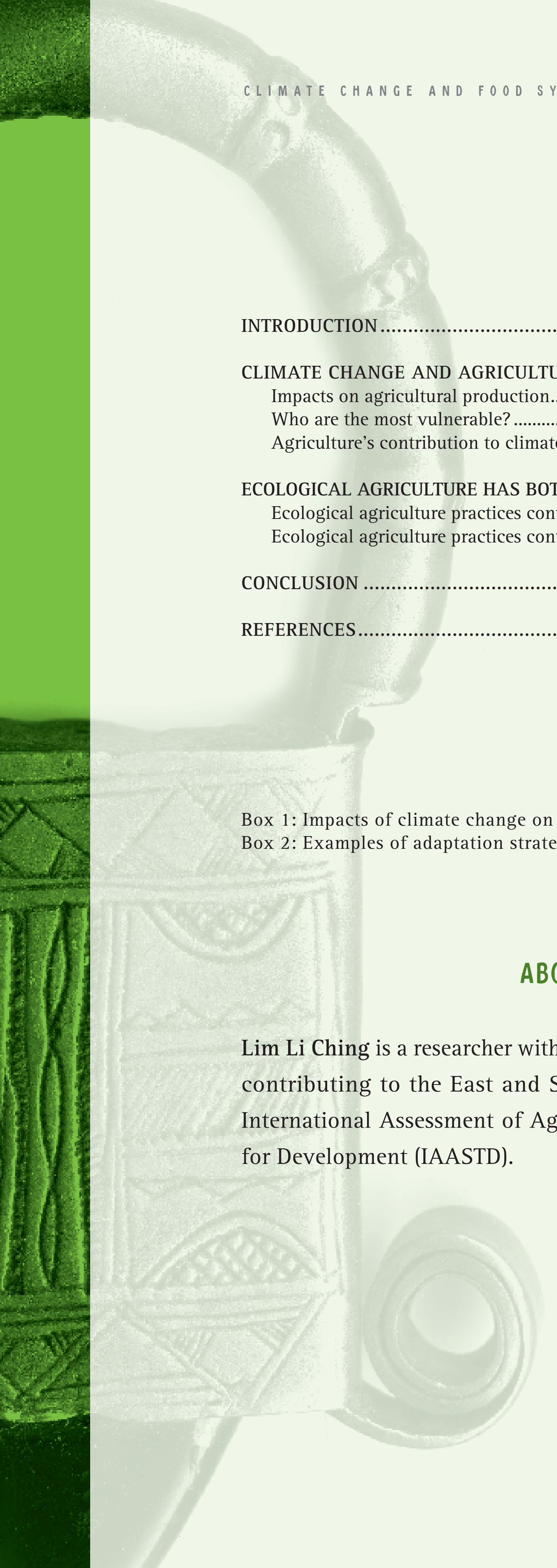

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ABOUT THE AUTHOR

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INTRODUCTION

One sixth of humanity is suffering from hunger – the Food and Agriculture Organization of the United Nations (FAO) estimates that 105 million more people were pushed into hunger in 2009, bringing the total number of hungry to a shameful 1.02 billion.

Add climate change to these statistics, and the situation becomes even more urgent. A recent report by the International Food Policy Research Institute (IFPRI) warns that unchecked climate change will have major negative effects on agricultural productivity, with yield declines for the most important crops and additional price increases for the world's staples – rice, wheat, maize and soybeans (Nelson *et al.*, 2009). It also suggests that there will be 20 percent more malnourished children in 2050 due to climate change.

According to the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD, 2009)[1], climate change, coincident with increasing demand for food, feed, fibre and fuel, has the potential to irreversibly damage the natural resource base on which agriculture depends, with significant consequences for food insecurity. Climate change could also significantly constrain economic development in developing countries that rely largely on agriculture (Rosegrant *et al.*, 2008).

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[1] The IAASTD is the most recent and comprehensive assessment of agriculture, co-sponsored by the World Bank, FAO, United Nations Environment Programme (UNEP), United Nations Development Prgoramme (UNDP), World Health Organization (WHO), United Nations Educational, Scientific and Cultural Organization (UNESCO) and the Global Environment Facility (GEF).

CLIMATE CHANGE AND AGRICULTURE

Impacts on agricultural production

The Intergovernmental Panel on Climate Change (IPCC) has projected that crop productivity would increase slightly at mid- to high-latitudes for local mean temperature increases of up to 1–3°C (depending on the crop), but further warming would have increasingly negative impacts in all regions (Easterling *et al.*, 2007; IPCC, 2007a). More significantly, for many developing countries, at lower latitudes, especially in the seasonally dry and tropical regions, crop productivity is projected to decrease for even small local temperature increases (1–2°C).

Moreover, it is changes in the frequency and severity of extreme climate events, such as droughts and heavy precipitation, which will have more serious consequences. Modelling suggests that increasing frequency of crop loss due to such extreme climate events may overcome any positive effects of moderate temperature increase (Easterling *et al.*, 2007). Increases in the frequency of droughts and floods are projected to affect local crop production negatively, especially in subsistence sectors at low latitudes (IPCC, 2007a).

On a global scale, the potential for food production is projected to increase with increases in local average temperature over a range of 1–3°C, but above this it is projected to decrease (IPCC, 2007a). This would increase the number of people at risk of hunger. Climate change alone is estimated to increase the number of undernourished people to between 40 million and 170 million, although impacts may be mitigated by socio-economic development (Easterling *et al.*, 2007).

For sub-Saharan Africa, including where some of the poorest people live and farm, the projections of climate change's impacts on agriculture are dire (see Box 1). New studies confirm that Africa is one of the most vulnerable continents to climate variability and change because of multiple stresses and low adaptive capacity (IPCC, 2007a).

BOX 1

IMPACTS OF CLIMATE CHANGE ON AGRICULTURE IN SUB-SAHARAN AFRICA

Agricultural production – including access to food – in many African countries and regions will be severely affected. 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 some countries, yields from rain-fed agriculture, which is important for the poorest farmers, could be reduced by up to 50 percent by 2020.

Yields of grains and other crops could decrease substantially across the continent because of increased frequency of drought, even if there are potential production increases due to increases in carbon dioxide concentrations. Some crops (e.g. maize) could be discontinued in some areas. Livestock production would suffer due to deteriorated rangeland quality and degradation of rangeland areas.

There is evidence that freshwater resources, on which the viability of agriculture depends, are vulnerable and will be strongly impacted by climate change, and that current water management practices may not be sufficient to cope with these impacts. By 2020, between 75 and 250 million Africans could be exposed to increased water stress. Coupled with increased demand, this will adversely affect livelihoods and exacerbate water-related problems.

As a consequence of these impacts, climate change is likely to further entrench food insecurity in sub-Saharan Africa. By 2080, about 75 percent of all people at risk of hunger are estimated to live in this region.

Sources: Easterling *et al.*, 2007; IPCC, 2007a & 2007b

Who are the most vulnerable?

It is the majority of the world's rural poor who live in areas that are resource-poor, highly heterogeneous and risk-prone, who will be hardest hit by climate change. In particular, smallholder and subsistence farmers, pastoralists and artisanal fisherfolk will suffer complex, localised impacts of climate change and will be disproportionately affected by extreme climate events (Easterling *et al.*, 2007). For these vulnerable groups, even minor changes in climate can have disastrous impacts on their lives and livelihoods (Altieri and Koohafkan, 2008).

With a large number of smallholder and subsistence farming households in the dryland tropics, there is particular concern over temperature-induced declines in crop yields, and increasing frequency and severity of drought, which will lead to the following general impacts: increased likelihood of crop failure; increased diseases and mortality of livestock and/or forced sale of livestock at disadvantageous prices; increased livelihood insecurity, resulting in sale of other assets, indebtedness, out-migration and dependency on food aid; and a downward spiral on human development indicators such as health and education (Easterling *et al.*, 2007).

Other physical impacts of climate change important to smallholders are decreased water supply for major smallholder irrigation systems, effects of sea level rise on coastal areas, increased frequency of landfall tropical storms and other forms of environmental impact such as remobilisation of dunes in semi-arid southern Africa. There will also be impacts on human health, such as increased malaria risk affecting labour available for agriculture and other non-farm rural economic activities.

Agriculture's contribution to climate change

The relationship between climate change and agriculture is however a two-way one; climate change in general adversely affects agriculture and agriculture contributes to climate change in several major ways.

Agriculture directly releases into the atmosphere a significant amount of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), amounting to around 10–12 percent of global anthropogenic greenhouse gas emissions annually (Smith *et al.*, 2007). Of global anthropogenic emissions in 2005, agriculture accounted for about 60 percent of nitrous oxide and about 50 percent of methane, both of which have far greater global warming impact than carbon dioxide. Nitrous oxide emissions are mainly associated with nitrogen fertilizers and manure applied to soils, as fertilizers are often applied in excess and not fully used by crops, so that some of the surplus is lost to the atmosphere. Fermentative digestion by ruminant livestock contributes to methane emissions, as does cultivation of rice in flooded conditions.

If indirect contributions (e.g. land conversion to agriculture, fertilizer production and distribution and farm operations) are factored in, it is estimated that the contribution of agriculture could be as high as 17–32 percent of global anthropogenic emissions (Bellarby *et al.*, 2008). In particular, land use change, driven by industrial production methods, accounts for more than half of total agricultural emissions.

Conventional industrial agriculture is also heavily reliant on fossil fuels. The manufacture and distribution of synthetic fertilizers contributes a significant amount of greenhouse gas emissions, between 0.6–1.2 percent of the world's total emissions (Bellarby *et al.*, 2008). This is because the production of fertilizers is energy intensive and emits carbon dioxide, while nitrate production also generates nitrous oxide.

While sub-Saharan Africa is a region where per capita food production is either in decline, or roughly constant at a level that is less than adequate, the rising wealth of urban populations is likely to increase demand, albeit slowly, for livestock products. This would result in intensification of agriculture and expansion to still largely unexploited areas, particularly in South and Central Africa (including Angola, Zambia, Democratic Republic of the Congo, Mozambique and Tanzania), with a consequent increase in greenhouse gas emissions. Hence, sub-Saharan Africa is, together with the Middle East and North Africa, projected to see the highest growth in emissions from agriculture, with a combined 95 percent increase in the period 1990 to 2020 (Smith *et al.*, 2007).

ECOLOGICAL AGRICULTURE HAS BOTH ADAPTATION AND MITIGATION POTENTIAL

The IAASTD clearly concluded that the "business as usual" scenario of industrial farming, input- and energy-intensiveness, along with damage to the environment is no longer tenable. In an era of climate change, the challenge is therefore to design an agriculture that adapts and responds to the changes in climate experienced, as well as reduces greenhouse gas emissions. This challenge could be met by ecological agriculture.

Sustainable and ecological agricultural approaches, including organic agriculture, can be in many forms, but generally integrate natural, regenerative processes; minimize non-renewable inputs (pesticides and fertilizers); rely on the knowledge and skills of farmers and depend on locally-adapted practices to innovate in the face of uncertainty (Pretty and Hine, 2001). Ecological agriculture is also biodiversity-based (Ensor, 2009), depending on and sustaining agricultural biodiversity.

Ecological agriculture is already practiced by many African smallholder farmers. Africa has approximately 33 million small farms, representing 80 percent of all farms in the region. Although Africa now imports large amounts of cereals, the majority of African farmers (many of them women) who are smallholders with farms below two hectares, produce a significant amount of basic food crops with virtually no or little use of fertilizers and improved seed (Altieri, 2008). They instead rely mainly on nature and natural processes, agricultural biodiversity, local resources and local knowledge to farm.

Any comprehensive strategy for addressing climate change must include both adaptation and mitigation (IFAD, 2008), and ecological agriculture has the potential to do both. For the most vulnerable people, whose livelihoods are being impacted now, adaptation is urgent. However, concerted and sustained mitigation efforts are also needed to prevent further deterioration in the medium term. Since adaptation becomes costlier and less effective as the magnitude of climate change increases, mitigation remains essential (Rosegrant *et al*., 2008).

Ecological agriculture practices contribute to adaptation

Adaptation can be both autonomous and planned. Autonomous adaptation is the ongoing implementation of existing knowledge and technology in response to the changes in climate experienced; planned adaptation is the increase in adaptive capacity by mobilizing institutions and policies to establish or strengthen conditions that are favourable to effective adaptation, and investment in new technologies and infrastructure (Easterling *et al.*, 2007). Autonomous adaptation is highly relevant for smallholder farmers in developing countries (IFAD, 2008). Crucially, many of these autonomous adaptation options are met by ecological agriculture practices, as highlighted below. By increasing resilience within the agroecosystem, ecological agriculture increases its ability to continue functioning when faced with unexpected events such as climate change (Borron, 2006; Ensor, 2009).

Resiliency to climate disasters is closely linked to farm biodiversity; practices that enhance biodiversity allow farms to mimic natural ecological processes, enabling them to better respond to change and reduce risk. Thus, farmers who increase interspecific diversity suffer less damage compared to conventional farmers planting monocultures (Altieri and Koohafkan, 2008; Borron, 2006; Ensor, 2009; Niggli *et al.*, 2009). Moreover, the use of intraspecific diversity (different cultivars of the same crop) is insurance against future environmental change. Diverse agroecosystems can also adapt to new pests or increased pest numbers (Ensor, 2009).

Ecological agriculture practices that preserve soil fertility and maintain or increase organic matter – such as crop rotation, composting, green manures and cover crops – can reduce the negative effects of drought while increasing productivity (ITC and FiBL, 2007; Niggli *et al.*, 2009). In particular, the water holding capacity of soil is enhanced by practices that build organic matter, helping farmers withstand drought (Altieri and Koohafkan, 2008; Borron, 2006).

Conversely, organic matter also enhances water capture in soils, significantly reducing the risk of floods (ITC and FiBL, 2007; Niggli *et al.*, 2009). Practices such as crop residue retention, mulching, and agroforestry conserve soil moisture and protect crops against microclimate extremes.

In addition, water-harvesting practices allow farmers to rely on stored water during droughts, or to increase water availability. For example, in many parts of Burkina Faso and Mali there has been a revival of the old water harvesting system known as 'zai'. The zai are pits that farmers dig in rock-hard barren land, into which water would otherwise not penetrate. The pits are filled with organic matter and attract termites, which dig channels and thus improve soil structure so that more water can infiltrate and be held in the soil (Reij and Waters-Bayer, 2001, cited in Altieri and Koohafkan, 2008).

Adaptive capacity is an active process that involves the ability of individuals or communities to modify and transform practices in response to climate change. Indigenous and traditional knowledge are a key source of information on adaptive capacity, centred on the selective, experimental and resilient capabilities of farmers (Altieri and Koohafkan, 2008; Borron, 2006; IAASTD, 2009; ITC and FiBL; 2007, Niggli *et al.*, 2009). Many farmers cope with climate change, in various ways: minimising crop failure through increased use of drought-tolerant or disease- and pest-resistant local varieties, water-harvesting, extensive planting, mixed cropping, agroforesty, opportunistic weeding and wild plant gathering (see also Box 2).

BOX 2

EXAMPLES OF ADAPTATION STRATEGIES FROM SOUTHERN GHANA

Farmers in Southern Ghana are adapting and coping with climate variability in various ways. This is manifested by the diversity of resource management and cropping systems, which are based on indigenous knowledge of management of the fragile and variable environment, local genotypes of food crops, intercropping, and agroforestry systems. These coping mechanisms not only help meet farmers' subsistence needs, but also encourage biodiversity conservation. To offset crop failure arising from rainfall variability and unpredictability, farmers cultivate hardier (or drought-tolerant) types of the same crop species. The planting of vegetable crops that can serve as a hedge against risk associated with drought is also a common practice.

Source: Ofori Sarpong and Asante, 2004, cited in Altieri and Koofhafkan, 2008.

Ecological agriculture practices contribute to mitigation

On the other hand, agriculture has the potential to change from being one of the largest greenhouse gas emitters to a much smaller emitter and even a net carbon sink, while offering options for mitigation by reducing emissions and by sequestering carbon dioxide from the atmosphere into the soil. The solutions call for a shift to more sustainable farming practices that build up carbon in the soil and use less chemical fertilizers and pesticides (Bellarby *et al.* 2008; ITC and FiBL, 2007; Ziesemer, 2007).

There are a variety of practices that can reduce agriculture's contribution to climate change. These include crop rotations and improved farming system design, improved cropland management, improved nutrient and manure management, improved grazing-land and livestock management, maintaining fertile soils and restoration of degraded land, improved water and rice management, fertilizer management, land use change and agroforestry (Bellarby *et al.*, 2008; Niggli *et al.*, 2009; Smith *et al.*, 2007). Many of these practices are inherent in ecological agriculture and easily implemented.

In particular, it is estimated that a conversion to organic agriculture would considerably enhance the sequestration of carbon dioxide through the use of techniques that build up soil organic matter, as well as diminish nitrous oxide emissions due to no external mineral nitrogen input and more efficient nitrogen use (Niggli *et al.*, 2009). Organic systems have been found to sequester more carbon dioxide than conventional farms, while techniques that reduce soil erosion convert carbon losses into gains (Bellarby *et al.*, 2008; ITC and FiBL, 2007; Niggli *et al.*, 2009). Ecological agriculture is also self-sufficient in nitrogen due to recycling of manures from livestock and crop residues via composting, as well as planting of leguminous crops (Ensor, 2009; ITC and FiBL, 2007).

Moreover, practices rooted in ecological agriculture, such as introducing perennial crops to store carbon below ground and planting temporary vegetative cover between successive crops to reduce nitrous oxide emissions by extracting unused nitrogen, also mitigate climate change (Ensor, 2009).

CONCLUSION

Climate change will undoubtedly pose serious challenges for African agriculture. Nonetheless, African farmers are well poised to adopt ecological agriculture, given that many of these sustainable practices are already in place and contributing to food production. Ecological agriculture is also an option that is easily accessible for Africa, where many farmers cannot afford expensive chemical inputs.

Redesigning agriculture in an era of climate change would entail investing more resources, research and training into, providing appropriate policy support to, and implementing national, regional and international action plans on ecological agriculture. Doing so will not only be beneficial in terms of climate adaptation and mitigation, but will also be a paradigm shift towards increasing productivity while ensuring sustainability and meeting smallholder farmers' food security needs (IAASTD, 2009).

Ecological agriculture is indeed productive, as shown by a review of 286 projects in 57 countries, whereby farmers increased agricultural productivity by an average of 79 percent, after adopting 'resource-conserving' agriculture (Pretty *et al*., 2006). A variety of sustainable technologies and practices were used, including integrated pest management, integrated nutrient management, conservation tillage, agroforestry, water harvesting in dryland areas, and livestock and aquaculture integration. The database was reanalysed to produce a summary of the impacts of organic and near-organic projects on agricultural productivity in Africa (Hine *et al*., 2008). The average crop yield increase was even higher for these projects than the global average: 116 percent increase for all African projects and 128 percent increase for the projects in East Africa.

Maximising the synergies between adaptation and mitigation means that these strategies should be developed simultaneously. In particular, Khor (2009) suggests the following:

- There should be more research and action on adaptation measures in agriculture, especially in developing countries in order to assist farmers there to reduce the adverse impacts of climate change on agriculture.

- Action plans for mitigation measures for agriculture should be urgently researched and implemented.
- Financing assistance for adaptation and mitigation measures in the agriculture sector in developing countries should be prioritised.
- Arrangements should be made for the sharing of experiences and the transfer of good practices in agriculture that can constitute mitigation and adaptation.
- Given the many advantages of organic farming and ecological agriculture, in terms of climate change as well as social equity and farmers' livelihoods, there should be a much more significant share of research, personnel, investment, financing and overall support from governments and international agencies channelled towards ecological agriculture. Promotion of ecological agriculture can lead to a superior model of agriculture from the environmental and climate change perspective, as high-chemical and water-intensive agriculture is phased out, while more natural farming methods are phased in, with research and training programmes also promoting better production performances in ecological agriculture.

With appropriate focus on ecological agriculture as providing adaptation, mitigation and increased productivity options, a "win-win-win" scenario for agriculture is possible.

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