

**ASSESSING AND ADDRESSING CLIMATE-INDUCED RISK
IN SUB-SAHARAN RAINFED AGRICULTURE**
FOREWORD TO A SPECIAL ISSUE OF EXPERIMENTAL AGRICULTURE

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Rainfed agriculture in sub-Saharan Africa (SSA) is the mainstay of the continent's food and feed production. Nearly 90% of staple food and feed production comes from, and will continue to come from, rainfed agriculture (Rosegrant *et al.*, 2002). In spite of this, investment in this vital production system, and hence its productivity, has stagnated. There are many complex and interrelated issues that contribute to this state of affairs. The outcomes of lack of investment and low production of rainfed agriculture reinforce each other leading to poverty traps and increased vulnerability of livelihoods to climatic and other shocks (World Bank, 2000). This has become well recognized and an emerging political will, both within and outside SSA, to support increased investment in rainfed agriculture appears to be gaining momentum (Sanchez *et al.*, 2009).

Nevertheless, for such investment strategies to produce the needed impact on a wider scale, favourable policies, institutional arrangements and basic development infrastructure are required for proper functioning of markets. An enabling investment policy environment would include the existence of proper incentives, market access, information, input supply systems and the institutions required to reinforce their use (Barrett *et al.*, 2002; Collier and Gunning, 1999). However, in many countries in Africa, low per capita incomes, debt servicing and negative balance of payments at the national level still undermine the ability of governments to invest in basic infrastructure needed for markets and the private sector to operate effectively. These issues all impinge on investment decisions taken by a range of stakeholders within the rainfed agricultural sector.

Simply put, the Green Revolution of the 1960s and 1970s that transformed agriculture in many parts of Asia has, thus far, largely bypassed Africa. The widespread adoption of improved cultivars and the essential use of mineral fertilizer to support greatly enhanced growth and yield were the foundations of the Green Revolution in Asia, but have just not occurred in SSA. This is exemplified by the average rate of fertilizer use which has risen ten-fold, from 5 to 50 kg ha⁻¹ in many parts of Asia and Latin America during the past 50 years whilst in Africa it has stayed at a very low average of about 5 kg ha⁻¹ (Figure 1).

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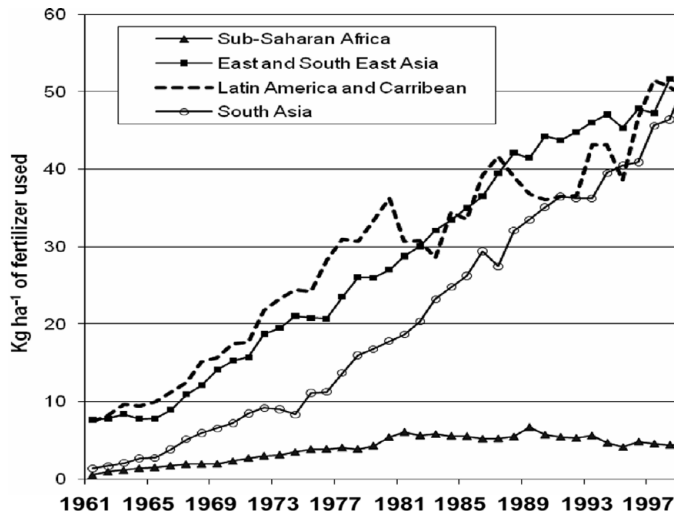


Figure 1. Fertilizer use trends (kg ha^{-1}) in Africa, Asia and Latin America (Source FAOSTAT).

Encouragingly, and in contrast to the wider picture of low fertilizer use in SSA as a whole, the recent introduction of subsidies on hybrid maize seed and fertilizer in Malawi has had a dramatic impact on the country's self sufficiency in maize production and has even allowed the export of maize grain to neighbouring countries (Denning *et al.*, 2009).

However, in spite of the encouraging signs of greater commitment to rainfed agriculture in SSA, there is one fundamental characteristic of this sector that cannot be ignored. Rainfall variability, both within and between seasons, creates an underlying risk and uncertainty for current farm-level production as well as for the potential impact of innovations designed to improve crop, soil and livestock management practices. This uncertainty discourages the adoption of improved farming practices and the beneficial 'investment' decisions required, not only from farming communities, but also from a wide range of additional agricultural stakeholders. Farmers, their supply agents and stakeholders often overestimate the negative impact of climate-induced risk. As a result, they show understandable reluctance to invest in potentially more sustainable, productive and economically rewarding practices when the returns to investment appear so unpredictable from season to season (Cooper *et al.* 2008).

Overlaid on this challenging scenario is the accepted prediction that, whatever happens to future greenhouse gas emissions, we are now locked into global warming and inevitable changes to climatic patterns which are likely to exacerbate existing rainfall variability in SSA and further increase the frequency of climatic extremes (IPCC, 2007). Indeed, evidence of changes in climate extremes, in particular with regard to temperature, is already emerging in Southern and West Africa (New *et al.*, 2006). '*Adaptation to climate change is therefore no longer a secondary and long-term response option only to be considered as a last resort. It is now prevalent and imperative, and for those communities already vulnerable to the impacts of present day climatic hazards, an urgent imperative*' (IISD, 2003).

Given the constraints of both current climate-induced production risk and the predicted change in nature of that risk in the future, it is now widely accepted that a two-pronged approach, sometimes referred to as the 'twin pillars' of adaptation to climate change, is needed (Burton and van Aalst, 2004, DFID, 2005, Washington *et al.*, 2006). Such an approach recognizes that short- and medium-term strategies are required.

Firstly in the shorter term, since rainfed farmers are already vulnerable to current weather variability and associated shocks, it is essential to help them to build their livelihood resilience through coping better with current weather-induced risk as a pre-requisite to adapting to future climate change. Not only will greater resilience allow farmers a wider range of adaptation options in the future, but perhaps more important is the consideration of the already substantial current season-to-season weather ranges and the extent to which these ranges will, or will not change in the future. Whilst temperatures are already increasing and changes in rainfall amounts and patterns may begin to become significant in the future, the question remains to what extent farmers will experience conditions under progressive climate change that they are not already experiencing today. This can be illustrated by a recent analysis of the simulated impact of a 3 °C rise in temperature on the length of growing period (LGP) at Makindu, a semi-arid location in Kenya (Cooper *et al.*, 2009). Using 45 years (1959–2004) of long-term daily weather data, the study showed that under current climates, the LGP of the short rainy season (October, November and December) ranged from 50 to 175 days, reflecting the large season-to-season variability of rainfall which during the 45-year period varied from 125 to 810 mm for the short rainy season. Whilst a possible 3 °C increase in temperature in the future reduced the mean LGP by about 8%, across the 45 years, the projected LGPs ranged from 48 to 152 days compared with the 50 to 175 today. In other words, in about 80% of the seasons that would occur in the future under the assumed 3 °C temperature increase, farmers would *still* be experiencing LGPs that they are already experiencing today. Notwithstanding the fact that such an increase in temperature will affect other aspects of crop production such as the rate of crop development and the likelihood of possible negative impacts from extreme temperatures, it is clear that helping farmers cope better with the scope of risk associated with today's weather variability will also be beneficial under tomorrow's warming climate change scenarios.

Secondly, however, it is accepted that in the medium to longer term and as climate change becomes more obvious, farmers will have to adapt their farming practices to a new set of weather-induced risks and opportunities.

Against this background, a wealth of information has emerged over the decades in SSA that has identified a broad range of tested and proven crop, soil, water, biodiversity and livestock management innovations, all of which are affected to a greater or lesser extent by the variable rainfall characteristics of any given season. Yet, as we have noted above, the adoption of such innovations has remained low. One contributing reason is that little, if any, associated information is available to farmers and their support agents with regard to the climate-induced risk associated with these innovations and the extent to which such innovations might mitigate or exacerbate such risk. Such

information would seem to be essential if risk-averse farmers are to make better informed and more profitable decisions and indeed for their support agents to more confidently promote innovative farming practice and to ensure the availability of the inputs required.

However, current climate-induced production risk and the probable implications of changes in the nature of that risk associated with global warming can now be quantified using a range of new and proven tools and approaches. There is increasing evidence that when the proper communication channels are in place, the quantification of such risk and its management can greatly support risk-averse farmers' decision-making process and hence enhance the adoption of more sustainable and productive farming practices (Carberry *et al.* 2004). In this special edition, studies are presented which illustrate the use of a range of such tools, their effectiveness, their limitations and some of their challenges.

This issue starts with a paper by Jarvis *et al.* (2011, this issue) which places our specific focus of assessing and addressing current climate-induced risk within the broader context of an integrated framework of adaptation to and mitigation of climate change. This overview is then followed by eight papers which describe specific aspects and approaches to climate risk assessment and management. The approaches covered in this issue include (i) a review of the value of seasonal climate forecasting (Hansen *et al.*, 2011, this issue), (ii) pioneering ideas for enhanced pastoral climate risk management (Ouma *et al.*, 2011, this issue), (iii) statistical approaches for the rainfall-induced risk and trend analyses of long-term weather datasets (Stern *et al.*, 2011, this issue), (iv) the use of weather-driven crop growth simulation models and weather generators for the *ex ante* assessment of the risk and profitability of agricultural innovations (Dixit *et al.*, 2011, this issue), (v) the combined use of real time and generated long-term weather data, together with satellite imagery, for assessing the risk of rainfall-associated outbreaks of bean root rots (Farrow *et al.*, 2011, this issue), the use of a weather-driven watershed scale model to predict the impact of land management practices on water and sediment yields under a range of land management and climate change scenarios (Gathenya *et al.*, 2011, this issue) and (vii) the combined use of farmer survey instruments and locally available weather data to assess the perceptions and realities of farmers' understanding of current climate risk and of climate change (Osbahe *et al.* and Rao *et al.*, 2011, this issue). We finish with a summary of what we feel are some of the overarching lessons and issues that have emerged from these studies and, where appropriate, some recommendations that we feel should be considered.

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