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Global agriculture needs smart science and policies

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Food insecurity and climate change, the twin crises that may define the future [1] have brought agriculture back into the spotlight of international debate. In spite of the growing threats of climate change to agricultural yields and livelihoods, global agriculture must produce additional food to feed a growing population [2]. Today, more than ever before, we understand the significance that climate has for agriculture. Major weather and food price shocks are becoming the new norm – the recent droughts in the horn of Africa, Russia, Australia, and United States markedly affected food production and prices, and increased the vulnerability of the poor.

Agriculture's direct reliance on the natural resource base is a defining characteristic of the sector, consuming 70% of global freshwater and occupying 40% of global land area. Conventional forms of agricultural production are often unsustainable, pollute the environment and deplete the natural resources on which production relies over time. Low agricultural productivity is often associated with poverty, food insecurity, and nutrient depletion in Africa, where just 4% of smallholder farmers use improved seeds, the average fertilizer application is 9 kg per hectare, and only 1% of arable land is under irrigation. In Asia, inappropriate irrigation practices lead to elevated methane emissions and salinization, and high nitrogen fertilizer levels to greenhouse gas emissions. Agriculture is the world's leading source of methane and nitrous oxide emissions, a substantial source of carbon emissions, and the principal driver behind deforestation worldwide. Some 30% of global greenhouse gas emissions are attributable to agriculture and deforestation.

The growing consensus on the need for a *climate-smart agriculture* (CSA) emerged largely out of awareness of the sector's negative impacts. More recently, this perspective of agriculture as a source of greenhouse gas emissions and environmental pollution has become more balanced, with a growing understanding of the environmental services the sector can provide if production is well-managed. CSA has shown promise for achieving productivity increase, enhanced resilience and reduced GHG emissions in different parts of the world [3]. In Niger, agroforestry techniques applied on five million hectares have benefited over 1.25 million households, sequestered carbon, and produced an extra half-million tons of grain per year. On Rwanda's fertile hillsides a project designed to better manage rainfall and reduce hillside erosion has almost doubled earnings to $1,925 per hectare, while the share of production sold rose from 30 to 65%. In Uzbekistan where the greatest problem is severe water stress, improved irrigation and drainage, land privatization together with market liberalization has enabled a doubling of wheat yields. In Brazil, regulatory reforms have markedly improved the incentive for private sector investment in agriculture and forest management.

The last few years have witnessed increasing momentum and support to elevate climate smart agriculture in the international agenda. These include the Hague Roadmap of Action [4], a common position by African Agricultural Ministers [5], the scientific WageningenStatement [6], and the Hanoi Communiqué [7]. However, policy actions have been slow to materialize at the global level [8]. Modest progress was recorded at the 17th Conference of Parties to the UNFCCC in Durban, South Africa, in November 2011, when the Parties asked the UNFCCC Subsidiary Body for Scientific and Technological Advice (SBSTA) to explore the possibility of a formal work program on agriculture. At COP 18 in Doha, efforts to implement a formal program that addresses the dreadful problem of food insecurity and agricultural adaptation to climate change ended without agreement – the issue was deferred to June 2013 for additional discussion.

The world needs to urgently scale up alternative agricultural practices that are socially and environmentally sustainable that takes natural resource limits and climate change into account. Climate-smart agriculture needs to be fully integrated into countries' overall development strategies, but also needs the participation of all parts of the society. For this to happen, better and more comprehensive empirical evidence is needed on the potentials of

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CSA. This special issue addresses science-policy integration for climate-smart agriculture. In the first paper, *The role for scientists in tackling food insecurity and climate change*, Beddington et al. discuss the role of researchers in providing information for smarter policies and investments in the context of achieving food security under climate change [9]. These include improved understanding of agriculture's vulnerability to climate change, food price dynamics, food waste and consumption patterns and monitoring technologies as well as multidisciplinary investigation of regionally appropriate responses to climate change and food security challenges. The authors also lay out measures necessary to use resources more efficiently, adapt agricultural systems to climate change and encourage healthier eating choices. They note that the urgent need for investments transcends current patterns and practices of food production, distribution and consumption.

In the second paper titled *From Climate Smart Agriculture to Climate Smart Landscapes*, Scherr et al. argues that for agricultural systems to achieve climate-smart objectives, they need to take a landscape approach. Climate-smart landscapes operate on the principles of integrated landscape management, incorporating adaptation and mitigation into development objectives. The key features of climate-smart landscapes include: climate-smart practices at the field and farm scale; diversity of land use across the landscape to provide resilience; and management of land use interactions at landscape scale to achieve positive social, economic and ecological impacts. Using examples from Madagascar, African Sahel and Australia Scherr et al. highlight the institutional imperatives for promoting and sustaining climate-smart agricultural landscapes

The importance of ecosystem approaches that combine food and energy production is highlighted in Integrated *food–energy systems for climate-smart agriculture* by Bogdanski. The author states that unless food and energy production are well balanced within the agro-ecosystem, energy will constitute a significant external input for smallholder farming systems. The win-win opportunities provided by integrated food-energy systems are illustrated with examples from developed and developing countries. Bogdanski calls for more scientific assessments to inform decision-making for upscaling proven integrated food-energy systems.

In the last paper, *Resorienting crop improvement for the changing climatic conditions of the 21st century*, Mba et al. highlight the role of smart crop varieties – those that are suited to a range of agroecosystems and farming practices, and resilient to climate change – in sustainable intensification. Additionally, they discussed the desirable qualities of "elite varieties" to include improved nutritional qualities and the ability to make more efficient use of inputs. Emerging biotechnology techniques relevant to plant breeding are also discussed. In concluding, Mba et al. catalogue the strategies to reposition plant breeding for the 21st Century, including broadened genetic diversity of crops, proper definition of breeding goals, innovating for result-oriented breeding, public-private partnership, and capacity enhancement for breeding at the national level.

Competing interests
The author declares that he has no competing interests.

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