Foreword

CIAT is launching a new publication series titled *Issues in Tropical Agriculture*, and the first item in the series is *Eco-Efficiency: From Vision to Reality.* At first glance, the term "eco-efficiency" calls to mind the oft-repeated, simplistic idea of "producing more with less." But when viewed in relation to the challenge of what William Laurance and Jeff Sayer call the impending "agricultural bomb," the importance of the eco-efficiency theme becomes clear.

In fact, humanity is one drought away from massive famine. All it would take is an episode of dry weather, typical of past drought events, in the North China Plain, the US Corn Belt, or the Indo-Gangetic rice-wheat region. Indeed, the global food supply is on such a razor's edge that, as I was writing this foreword, a short heat wave without rain predicted for the US Corn Belt in the following week (24-30 June 2012) caused global maize prices to rise by 20% within just a few days. Since 2005, price spikes larger than this have occurred for rice and wheat, when drought or floods have occurred in a major crop production domain.

But the agricultural bomb is not just a warning about the need to increase production, because we live on a spaceship with finite resources. Land and water of adequate quantity and quality to support agricultural systems for a human population of 9 billion or more by 2050 are already in short supply. While there is some additional land suitable for agriculture in remnant rainforests, wetlands, and grassland savannas, bringing this land into food production would incur unacceptable costs in terms of greenhouse gas emissions and loss of climate regulation and biodiversity.

As a result, it is time to reach a global consensus on the explicit goal of meeting future food demand with the existing agricultural area—a goal that concedes conversion of an additional 100 million hectares of natural ecosystems to replace current crop land expected to be lost to urbanization and industrialization by 2050 (or about 7% of the current area used to produce annual crops).

Likewise, the manner in which crops and livestock are produced on existing farmland can have devastating negative impacts on the environment, human health, and greenhouse gas emissions. So, the challenge is not only to raise yields fast enough on existing farmland but also to do so using methods that reduce the environmental footprint of agriculture. And the scale of reduction in negative environmental externalities must be substantial: Nitrogen- and water-use efficiencies must increase by more than 50% in some of the world's major crop production systems; farming systems must be improved to reverse current trends of soil degradation and to maintain or increase organic matter levels; and net energy yields must double.

We are left with the realization that business as usual will not achieve a food-secure world on existing farmland without unacceptable loss of environmental services, because trajectories in crop yield advances and in the environmental impact of agriculture are simply not good enough. Hence, it can be argued that the single greatest scientific challenge facing humankind is generating the knowledge, technologies, and policies that can achieve the ecological intensification of agriculture that is required.

This brings us back to the concept of eco-efficient agriculture. As defined in CIAT's *Strategic Directions*, the concept focuses on increasing productivity while decreasing negative impacts on natural resources through approaches that meet

the economic, social, and environmental needs of the rural poor. It seeks to integrate the economic, environmental, and social elements of development, and strives toward solutions that are competitive, profitable, sustainable, and resilient in the face of an uncertain climate. The concept also takes into account the fact that increasing crop yields is necessary, but not sufficient, to avoid conversion of natural ecosystems; effective policies and good governance are also needed. Eco-efficiency further assumes that there are no silver bullets and that dealing with tradeoffs and using integrative and interdisciplinary approaches are essential. Finally, it recognizes that almost every future climate scenario already exists somewhere in the world today, such that helping develop eco-efficient solutions for poor farmers who struggle to feed their families in those environments is among the best research investments for adaptation to future climate change.

The papers in this inaugural publication cover a number of promising technology packages and much exciting science aimed at making agricultural systems more eco-efficient. But it is also clear that a number of gaps and emerging issues remain.

There is a critical need for robust, low-cost, reproducible metrics to quantify the impact of agriculture on environmental quality and human well-being. A new area of "metrics research" must emerge to provide the scientific underpinning for developing a set of integrative parameters that adequately monitor the performance of agricultural systems from field to watershed and global levels.

Likewise, there is a need for improved methods to anticipate and quantify tradeoffs at different spatial scales. For example, while organic agriculture may reduce the environmental footprint of agriculture locally, it may result in large negative impact at the global level. This could occur if organic systems are widely adopted and have lower yields per unit land area and time than conventional systems, which would encourage conversion of natural ecosystems and associated loss of environmental services and greenhouse gas emissions to meet future food demand.

Therefore, one of the grand challenges for CIAT, and indeed for the CGIAR and its partners, is to conduct research and support development efforts that lead to quantum leaps in the eco-efficiency of agricultural systems of greatest importance to the poor in developing countries. We are in a race against time, and there is no time to lose.

Kenneth G. Cassman
Robert B. Daugherty Professor of Agronomy, University of Nebraska, Lincoln, Nebraska, USA.
kcassman1@unl.edu