Systems modelling for Agriculture and Food Security

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The sustainable intensification of food and fiber production across the OECD divide presents distinct but equally complex challenges—each demanding fresh scientific approaches and innovative tools. In low-income countries, smallholder farmers face systemic barriers: scarce resources, weak market access, and inadequate infrastructure limit both opportunities and incentives to transform production systems. In high-income countries, meanwhile, farmers are approaching diminishing returns, where further gains are often uneconomical, environmentally unsustainable, or fraught with risk.

Despite modest progress since COVID-19, the world remains far from eradicating hunger and food insecurity by 2030 (SDG Target 2.1). At the same time, the global population is projected to surge by nearly 20% by 2050, reaching 9.6 billion, while climate change intensifies and reshapes agricultural realities.

Meeting rising demand for food and energy under these conditions requires more than incremental tweaks—it calls for bold innovation and the application of new scientific paradigms. Yet crop research has long been fragmented across disciplines. While breakthroughs have occurred, recent progress has been incremental, leaving the future outlook contested and uncertain.

Agriculture today is entangled in “wicked problems”—issues that cut across disciplines, knowledge systems, and values. Tackling them demands transdisciplinary, integrative, and forward-looking solutions.

Opportunities for such approaches emerge across interconnected scales: from genotype to phenotype, phenotype to crop, crop to farming system, and farm enterprise to agro-ecosystem. Crucially, farmers do not simply grow crops—they manage cropping systems, juggle scarce resources, and balance diverse objectives across multiple enterprises. Recognizing this complexity is the first step toward meaningful improvement.

In this presentation, I will focus on that step: shifting the lens from modelling crops to modelling farms and farmers. I will then return to highlight critical opportunities where crop modelling and physiology can sharpen our predictions and elevate the quality of our models.