AGRICULTURE AND THE ENVIRONMENT: A CODEPENDENT FUTURE REQUIRING NEW TECHNOLOGY, SYSTEMS AND EXPERTISE

Warren Parker

Landcare Research
PO Box 40, Lincoln 7640, NEW ZEALAND

Introduction

Agriculture's future growth is inextricably tied to improved environmental management. This paper provides a brief overview of the mega-trends shaping the future of agriculture and the operating context for farmers. This perspective of the future highlights where agriculture needs to adjust over the next decade in order to ensure its on-going success and also signals where farmers need to adapt their production systems and acquire new knowledge and skills.

The global context

As well-documented elsewhere, agriculture faces, on one the hand, a very positive future buoyed by rising global demand for food and fibre.[1,2,3] This is driven by factors such as population growth,[4] increasing wealth in developing economies, shifts in consumption patterns, and demographic change. The rapid emergence of the bioenergy and biomaterial sectors, increased industrialised livestock production, the loss of land from agriculture, and the decline in the supply of wild foods[5] as the habitats that provide these are either lost or excluded from harvest, are supporting the growth in demand for agricultural products.

On the other hand, agriculture faces a technically and socially challenging future due, first, to biophysical limits being reached for the essential natural resources and ecosystems that underpin agricultural production and, second, its need to maintain legitimacy with the public (or 'social license to operate') with respect to the effects of intensive agriculture on the environment and animal welfare.

The convergence of increased agricultural output and greater pressure on the natural resources and ecosystems supporting it means that global food and fibre supply and demand are increasingly tightly matched. Manifestations of this include growing concern about food and energy security, and greater price volatility for agricultural commodities compared with the past. One response to sovereign risk, the trans-national purchase of (or the acquisition of rights to) natural assets such as land, water and nutrients (e.g., potash), has stimulated debate on what is appropriate public policy for the ownership of these assets. Another response, the imposition of more rigorous requirements for environmental policy, has increased compliance costs for the users of natural assets (notably land and water). Responses of this kind are expected to increase in the future.

Some environmental challenges, such as avoiding dangerous climate change and halting the loss of biodiversity,[6] can be mitigated to some extent by local action but ultimately require complex multilateral agreements (e.g., the Kyoto Protocol and the Convention on Biological Diversity) to achieve an enduring solution. Negotiating robust settlements on these matters is protracted because the local impact on agriculture is not always clear, the science is disputed and the demands of other sectors take precedence. Change can therefore be slower than the rate of environmental degradation, and this elevates the risk of some ecosystems being irreparably harmed and generates more challenges to farmers' license to operate. Further, with present technology and farming systems, abatement options are frequently expensive for producers to implement without some form of assistance because they contribute more to an inter-generational public good than short-term private benefit. This can be seen, for example, with respect to climate change. Jaggard *et al.*[7]

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indicate that by 2050 greenhouse gas (GHG) concentrations in the atmosphere are likely to be 550 ppm, ozone concentrations 60 ppb, and temperatures 2°C warmer. CO_2 enrichment could increase crop yields by 13% but the higher ozone levels could decrease yields by 5% or more. There will be other changes too, such as increased levels of soil-borne pathogens. Current producers, even those experiencing more extreme weather conditions, are unlikely to demand technologies for these circumstances. However, forecasts of this nature, in spite of their imperfections, are important because they direct the focus of long-term research programmes to close technology gaps and support the design of sustainable future farming systems.

The continued urbanisation of societies,[8] including the development of mega-cities, presents opportunities to agriculture with respect to food, feed and fibre demand but also challenges in terms of retaining and attracting labour, reduced political power and influence, and less empathy with the role of farming in society (i.e. a widening rural:urban divide).

Managing through the transition period

While the drivers of change for farmers have been in place for many years, the public policy and social pressures to respond have become more prominent in the past decade. Adjustment to national and international policy for climate change and water management, for example, are beginning to take hold, and in many cases change is now being led by consumers and business.[9] Rather than wait for governments, forward-looking businesses have identified that they can strengthen their competitive advantage by lowering their environmental footprint, building their brand through independently verified environmental credentials, servicing the rapidly growing need for renewable energy and other environmentally 'friendly' technology, and supplying environmentally discerning consumers. Paradoxically, even though the mid- to long-term outlook is positive, a number of farming (including horticultural) businesses face difficult financial circumstances due to fragmentation of supply chains and marketing, lack of on-farm innovation, reduced competitiveness relative to emerging economies (e.g., Brazil), and poor capital structures due to high-priced land. This suggests further significant agrarian reform will occur over the next decade driven by factors such as bilateral free trade agreements, the rapid transfer of leading-edge agricultural technologies to emerging economies with lower cost structures and more abundant natural resources than developed economies, and lingering adjustments to the 2008 global financial crisis. To meet increases in the world demand for food, feed and fibre the on-farm trends of intensification and increased scale will continue.

Focus areas for a successful future

The context outlined earlier highlights areas on which agriculture should focus to ensure it successfully adjusts to natural resource constraints, ecosystem limits, new technology, and changing consumer markets and public expectations.

- *Sustain public investment in agricultural research & development*: While the level of public investment in agricultural R&D varies between countries, on a global basis this has declined, especially in applied disciplines[3]. Private sector investment has increased and is now dominated by six multinationals[10] with an associated concentration of intellectual property particularly with respect to agricultural chemicals, seeds and biotechnology. Areas that merit focus[3,10] include resource-use efficiency, natural resource substitutes, GHG mitigation and climate change adaption, renewable energy, aquaculture and wild marine farming, urban food production (e.g., green roofs), waste minimisation (on- and off-farm), pest management (including biocontrol methods), system redesign (on-farm and supply chains), and policy instruments to encourage better management of natural resources (e.g., payments to land owners for the provision of ecosystem services). It is inevitable that demand for on-farm use of genetic modification and other controversial step-change technologies will increase.

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- *Manage agriculture's brand and public image*: Food and agricultural technology companies are quickly learning that the power exercised by NGOs and consumers through social media can harm sales, prevent technology use, and erode brand value. Responsibility for managing agriculture's image rests at both the farm and industry level. Social media provides the opportunity to engage the public and consumers in novel ways (e.g., Icebreaker's baa code[11]) and to build understanding of farm production methods.

- *Align technology transfer to support farmers make complex decisions*: The dimensions of on-farm decisions have broadened from production and profit (through to the early 1990s) to encompass environmental effects, the knowledge and skills of farm labour, public perception, supply chain requirements, and risk management. In emerging areas such as climate change mitigation there may be few or no precedents from which best practice can be derived, requiring the farmer and his/her advisor to develop solutions from first principles. With this context in mind, decision support tools and advice packages need to provide the integrated framework and knowledge-base to farmers. And, as farmers on average are getting older (see below) consideration needs to be given to their most effective means of learning.

- *Development of new policy instruments to encourage and reward good environmental stewardship*: Agriculture generates both ecosystem regulating and provisioning services (e.g., carbon sequestration, nutrient cycling) and disservices (e.g., loss of habitat, sedimentation)[12]. With improved models for integrating spatial and temporal data there appears to be potential to develop policies and farm practices that encourage provisioning services and reduce the need to trade-off the environmental impacts of intensification.[12] This would complement other voluntary and regulatory approaches to land (and water) management.[13]

- *Information and communication technology (ICT) to support automation and real-time monitoring*: Productivity gains in agriculture and environmental compliance are increasingly enabled by ICT. Telemetry systems now enable real-time and predictive monitoring of farm performance to support optimal use of natural resources and minimise non-compliance risk. Interoperability of databases allows farmers to obtain data from multiple sources (e.g., from the market, processors and regulators) in order to customise information for decision support.

- *Farm business models to support succession and new entrants*: The average age of farm owners is increasing in developed economies. Combined with larger scale farming businesses, this has longer term implications for the introduction of new entrants into the industry and the rate of innovation. Over the past decade, as land values rapidly appreciated, share farming models, at least in the New Zealand context, diminished in favour of equity-sharing arrangements. While land and water are scarce resources, and their value is underpinned by aspects other than agricultural output, alternative business models are required to introduce younger, new entrants to farming.

- *New generation agricultural leadership*:[14] As outlined above, over the next decade or so, agriculture will be in transition – first, to low carbon and renewable sources of energy (e.g., plant derived, hydrogen, solar); second, to navigate beyond biological limits and degradation of natural resources while increasing outputs (i.e. farm system redesign for sustainable, low environmental footprint production); third, to provide products and services to rapidly changing markets (e.g., in New Zealand's case exports servicing Asian markets); fourth, from largely being a provider of data to others for compliance purposes to an active participant in information networks involving multiple parties for mutual benefit; and, fifth, to new governance arrangements for resource management, including for ecosystem services (e.g. ,water, carbon, nutrients) and co-management with indigenous peoples. Successfully negotiating agriculture through this transition will require skilled and visionary leadership. Adversarial advocacy will not suffice. Rather, leadership and expertise is needed to assemble high quality evidence to support policy formation and 'see the way' through seemingly intractable (i.e. so-called 'wicked'[15]) problems. To achieve this, agriculture must intentionally foster a new generation of leaders to take up this challenge.

Summary

Agriculture's positive future and long-run prosperity is particularly dependent on implementing practical solutions to enable the sustainable use of natural resources and ecosystem services in farming. Fortunately the truism, that "within every problem there also lies an opportunity" applies in this setting too. There are big opportunities within agriculture for initiatives such as resource-sparing technologies, environmental monitoring systems, re-designed production systems, low carbon supply chains, and policy instruments that reward good on-farm stewardship of ecosystem services. Achieving the transition to a sustainable agriculture will require effective rural leadership, a commitment to increased investment in agricultural R&D, and new ways of engaging and supporting farmers to develop solutions to the complex, multi-dimensional challenges associated within environmental management.

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